AMERICAN ENGINEER AND RAILROAD JOURNAL.

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OIL FUEL FOR LOCOMOTIVES.

Hoosac Tunnel,

Boston & Maine Railroad.

(For previous article see page 185.)

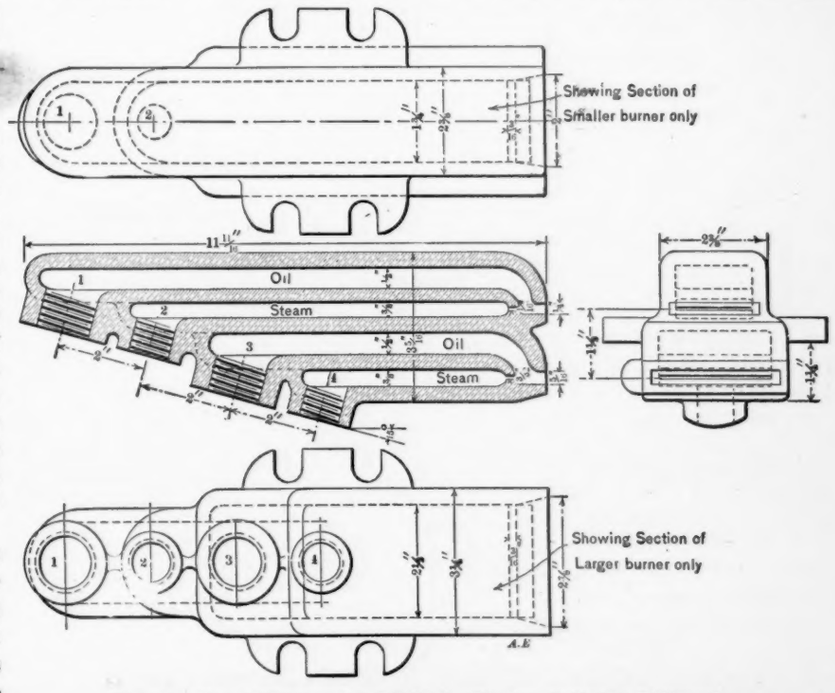
In the June issue lack of space prevented us from referring in detail to the interesting oil burner in use upon the Hoosac Tunnel helper locomotives in connection with the descriptive article. This burner is shown in detail in the accompanying drawing. It consists of two separate burners of different sizes, arranged in a single casting, the smaller one above and the larger one below. The slot type of burner is used instead of the nozzle type, as having been found more suitable for burning large quantities of oil and for forcing. It is of extremely simple construction, but is not troubled by stopping up. The variable service of the helper engines led to the design of the double burner, with one burner large enough to meet the demand of the heaviest loads and the other small enough to burn steadily with the least possible amount of steam and oil when the engine is waiting for service; the smaller burner was, however, found large enough to be capable of sufficient forcing to carry a train load in an extreme case of accident to the other burner.

In the latest design of this burner it has been changed so that the upper small burner is reversed from the arrangement shown in this sectional view, in order to place the steam passage above the oil passage. This causes the steam jet to blow from the surface of the oil as it feeds up from the oil passage, thus insuring a steady feed and no trouble from gasification of the thin layer of oil in the oil passage, and consequent breaking of the fire, as with the former arrangement when the valve is cut down for a low fire. The burner is set in the firebox 2 ins. below the firebox ring and 2 ins. above the brick in the pan, permitting an opening for air around the burner, which is desirable for keeping up combustion before the flame strikes the arch.

Mr. W. D. Hoffman, the engineer in charge of installation, is of the opinion that there is no benefit to be derived from an admission of air through the burner itself, as the volume of air that could be passed through the necessarily small opening in a burner would be of no consequence as compared with the large amount necessary for combustion. When admitted outside and around the burner, the harder the burner is forced the more air will be drawn in to support combustion in the flame before it reaches the arch, where the necessary larger volume of air is admitted through the damper. The burner is inclined upward at an angle of 15 degrees, so that the flame will strike about the middle of the arch wall, and then rebound toward the top of the firebox.

In operation, the greater the amount of steam used the greater the amount of oil burned, so that the fireman is called upon to use as much judgment here as with coal burning. In starting one of these burners, after first blowing out to clear of water, the steam valve is opened, so as to blow slightly from the burner, and then oil is turned on until the combined blast is ignited by the hot brick arch, or by a small fire of burning waste, if the firebox is cold; then both the oil and steam are regulated until the proper fire is obtained. In changing the fire, the steam is always opened up before the oil in increasing it, and in shutting down the oil is cut off first.

The throttling valves used in the steam and oil supply pipes are plug valves, in which the holes in the plugs are enlarged at their ends by tapering grooves cut in the circumference of the plug, so as to permit more gradual adjustment of the flow; these have been found more satisfactory than either globe or needle valves. The stems of the valves extend up through the floor of the cab to handles within easy reach of the fireman, and thus indicate by their position the opening of the valve. The blower connection is left in place, but is used only in case



Construction of Burner for Oil Fuel.—Boston & Maine Railroad.

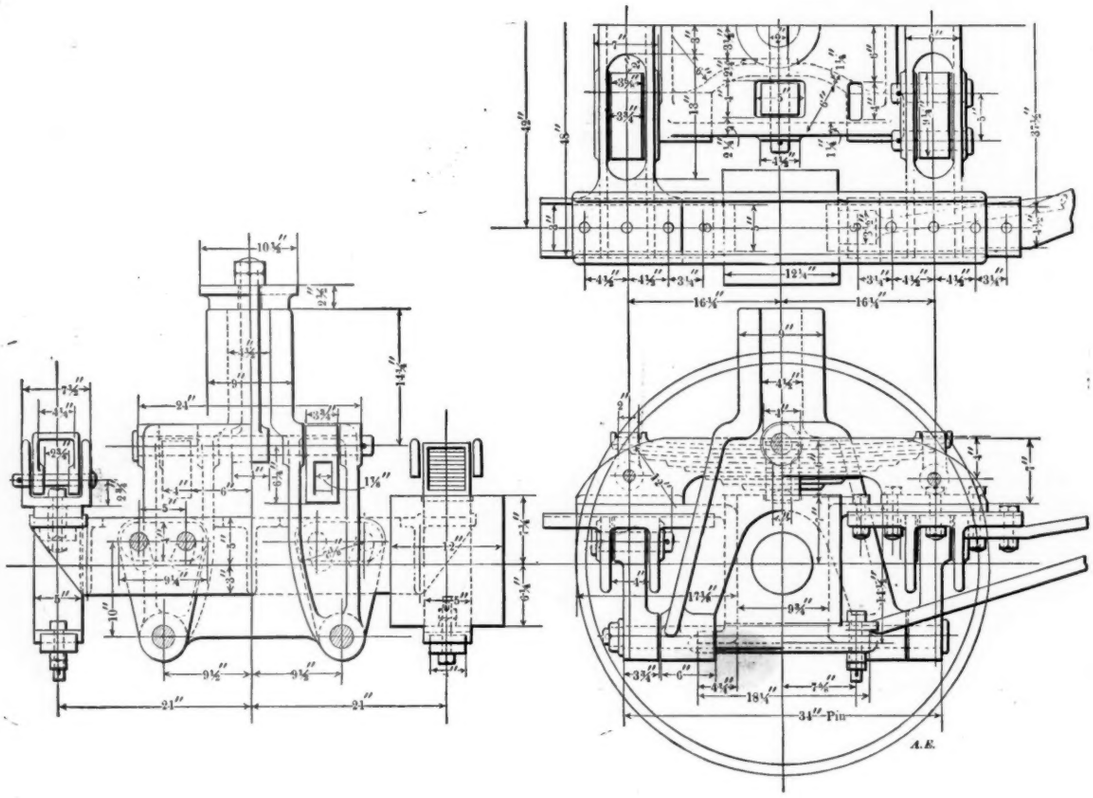
of very sudden stoppage of the engine, as the air pump exhaust is not sufficient to furnish draft.

The success of oil burning on these engines is interesting, in view of the peculiarly severe service to which they are subjected; they are in service for the entire twenty-four hours, having two crews, and are called upon at very irregular intervals and on very short notice. Also in the tunnel the fireman has to judge his fire entirely by its appearance, as it is impossible for him to see the stack. But they require no hostler service, no ash pit cleaning, no repairs to front end diaphragm and netting, and repairs do not appear to be increased by the oil burning. By closing the dampers the engine may be left for four or five hours without fire, and then be gotten ready for service in a very few minutes; in one instance one of the oil-burning engines, after having stood 15 hours without fire, showed 150 pounds' pressure at the gauge in just 40 minutes after the fire was started, and in another instance steam was raised to 150 pounds pressure from cold water in the boiler in 90 minutes after starting burner. When the engine is cold, the burner is started with steam from another engine, the blast being ignited by throwing a handful of oily waste in the firebox in front of the burner and lighting it with a torch.

In the tunnel the fireman can easily tell whether the fire is burning properly, or is smoky, by looking through the peep hole in the firebox door. After reaching the top of the grade at the middle of the tunnel the large burner is shut off and the small one started with a low fire for the remainder of the run, which is down grade.

It may be added that there is no possibility of damage to property along the line by sparks with the oil burners. In standing idle for some time, with a low fire, a coating of soot is liable to form in the tubes, but the soot is easily removed while the engine is working hard by simply throwing a small handful of sand into the firebox, which under the action of the strong draft effectually scours the tube surfaces clean. It is the opinion of Mr. Hoffman that no soot forms when the engine is working hard, but that with a light fire the hot gases are partially condensed by the cooling action of the large tube surface before combustion is complete. The change in the condition of the tunnel resulting from the use of oil fuel on the helper engines is very apparent, even with only two of them in service; in the opinions of employees that have been on that section of the road for several years, the tunnel has never been so clear as since the oil burners have been in operation.

The engines, 1072, 1073 and 1075, are Vauclain compound consolidations, with 15 and 25 by 24-in. cylinders, while the 1068 differs only in that it is a simple consolidation, with 20 by 24-in. cylinders. All are similar in principal dimensions, having total weight, with tender, of 225,000 pounds, weight on drivers of 121,000 pounds, and heating surface of 1,856 square feet.



Leading Truck, Prairie Type Locomotive.—A. T. & S. F. Railway.

Ton-miles are necessary to know what use superintendents are getting out of their power and out of their cars, what use the road as a whole is getting out of its plant, how far it is balancing its traffic, whether the fault of decline in net earnings lies with the traffic department or the operating department, and finally whether the service or commodity which the railroad is offering in the public market is declining in value more rapidly than the cost of producing it. These are the conditions on which the entire value of the property must ultimately rest, regardless of what may be its book capitalization. —J. Shirley Eaton, in *Railroad Gazette.*

TRUCKS AND FRAMES—PRAIRIE TYPE PASSENGER LOCOMOTIVES.

Atchison, Topeka & Santa Fe Railway.

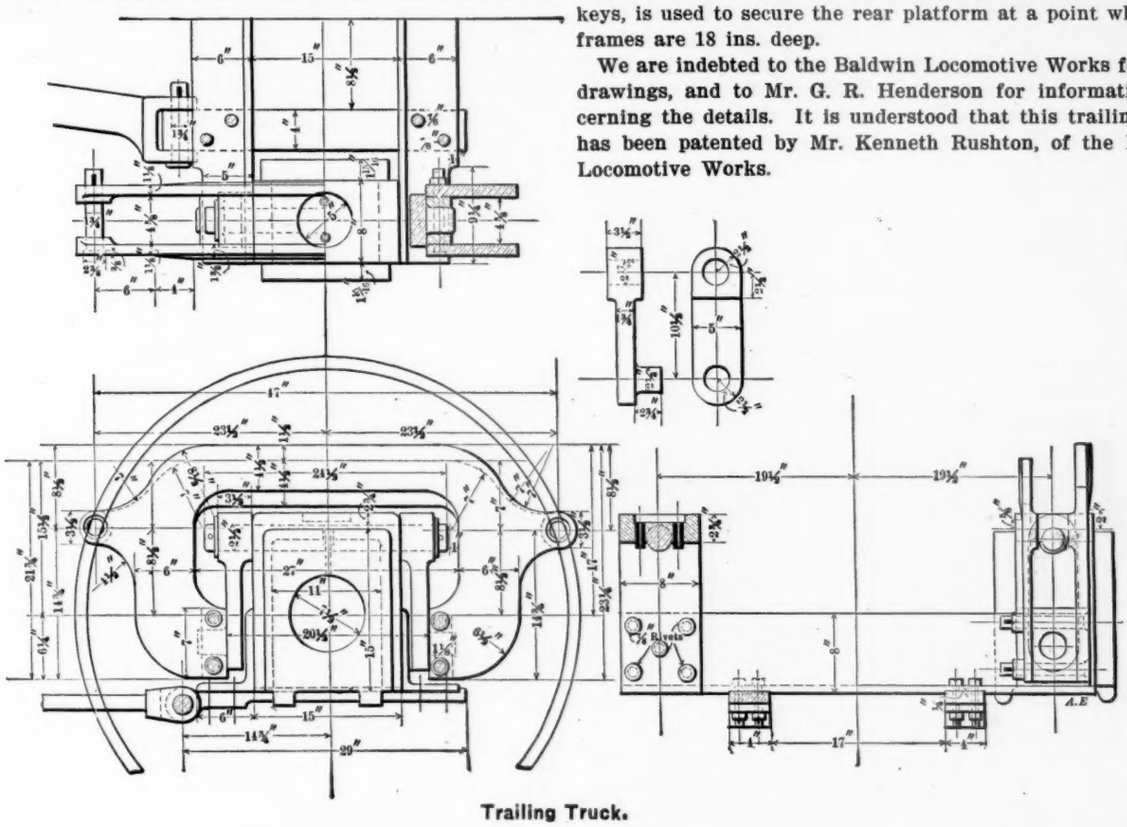
A general description of the very heavy prairie type passenger locomotives built last year by the Baldwin Locomotive Works for the Santa Fe, was published in this journal in December, 1901. Additional drawings of the interesting leading and trailing trucks and the frame construction have been received.

This design required a low front truck, and in accordance with suggestions from Mr. Henderson a combination using three-point hangers and leaf springs was effected in such a way as to keep the springs out of the way of other parts. In fact, the spaces occupied by the springs, which are flat, could not be used for any other purpose, as a glance at the drawing will indicate. This arrangement includes two equalizers, one at each side of the truck center. When the truck turns on a curve one of the equalizer hangers swings forward and the other swings back. The pin forming the bearings for the hangers is in double shear, because of the form of the casting. This arrangement is compact, and it seems to include all the features usually desired in trucks of this type.

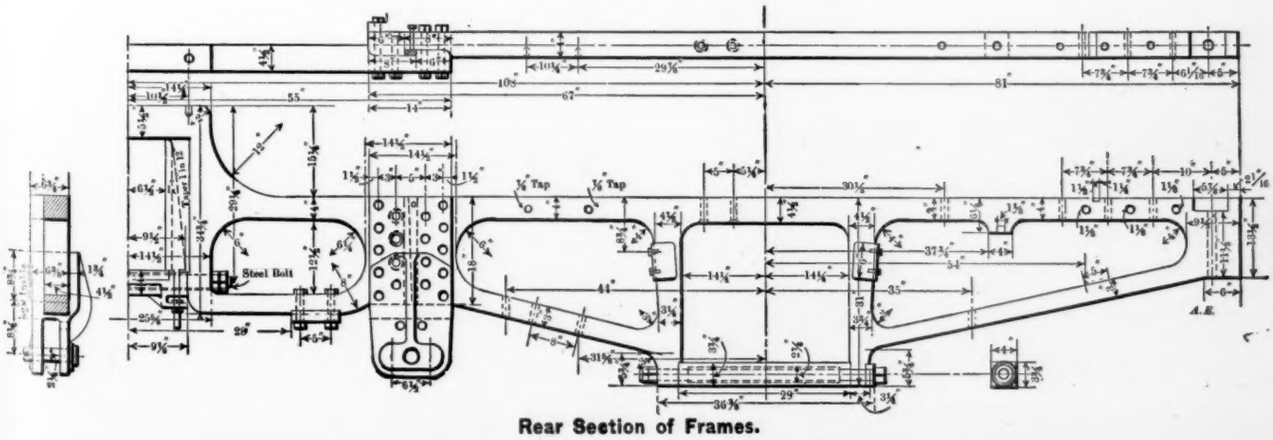
To accommodate the trailer truck, which is also of the radius bar type, and to provide for the large amount of motion required by so long a wheel base the frame jaws are unusually far apart, as shown in the frame drawing. The truck drawing shows the method of suspension, and the attachment of the springs may be seen in the elevation view of the engine on page 372 of the December number of last year. The lower ends of the swing links terminate in trunnions, with bearing blocks between the ends of the equalizer plates.

Because of the large size of the engine and the construction of the frames in three parts with two splices, the rear part of the frame drawing is shown. The rear end of the front rail terminates in a palm, which is secured by two compression keys in addition to the bolts. Another splice, with compression keys, is used to secure the rear platform at a point where the frames are 18 ins. deep.

We are indebted to the Baldwin Locomotive Works for these drawings, and to Mr. G. R. Henderson for information concerning the details. It is understood that this trailing truck has been patented by Mr. Kenneth Rushton, of the Baldwin Locomotive Works.

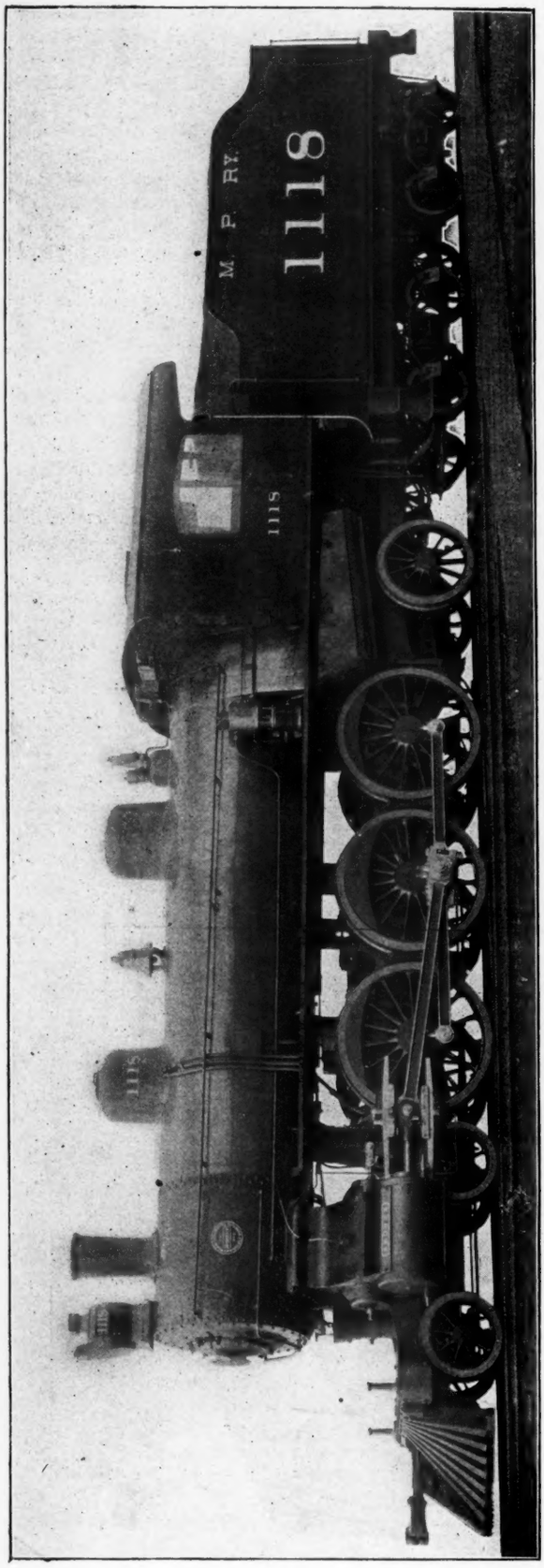


Trailing Truck.



Rear Section of Frames.

Trucks and Frames, Prairie Type Locomotives.—Atchison, Topeka & Santa Fe Railway.



Six Coupled Passenger Locomotive.—Missouri Pacific Railway.
Built at the Brooks Works of the American Locomotive Company.

NEW SIX-COUPLED PASSENGER LOCOMOTIVE.

Chesapeake & Ohio Railway.

Missouri Pacific Railway.

This type of wheel arrangement, while not entirely new, was devised to meet new conditions. Under the Whyte classification it is the 4-6-2 type and was decided upon because of the necessity of large tractive power combined with large heating surface and grate area. This required six-coupled wheels for both designs, also wide fireboxes. For heavy grades large boiler capacity was needed, and this required wide grates. Naturally one would turn to the 2-6-2 or Prairie type for such work as the Chesapeake & Ohio and the Missouri Pacific have to do, but because of the crooked roads and fast running which always occurs on mountain lines four-wheel leading trucks were decided upon as being safer than two-wheel trucks, although there is a difference of opinion upon the relative safety of the two. The Chesapeake & Ohio engines were designed under the direction of Mr. W. S. Morris when superintendent of motive power of this road, and the Missouri Pacific design was made in accordance with the views of Mr. J. O. Pattee, formerly of that road.

The Chesapeake & Ohio engines, built at Schenectady, weigh 187,000 lbs. in working order, with 131,000 lbs. on drivers. They have 22 x 28-in. cylinders, 72-in. driving wheels, 3.533 sq. ft. of heating surface and 47 sq. ft. of grate area. The tractive power is 32,000 lbs. These engines have tubes 19 ft. 6 ins. long.

The Missouri Pacific engines, built at the Brooks Works, weigh 173,000 lbs. in working order, with 120,000 lbs. on drivers. They have 20 x 26-in. cylinders, 69-in. driving wheels, 2,952.5 sq. ft. of heating surface and 42.4 sq. ft. of grate area. The tractive power is 25,600 lbs. These engines have tubes 18 ft. 6 ins. long.

It will thus be seen that the Chesapeake & Ohio design is much heavier and more powerful than the other. In fact there are but three passenger engines noted in our record, printed in June, heavier than this design. In 1892 the Chicago, Milwaukee & St. Paul applied trailing wheels to a 10-wheel engine, probably in order to overcome some defect in the distribution of weight, but this type is now designed purposely for certain definite conditions. The photograph shows one of the Missouri Pacific engines. In a later issue further illustrations of both designs will be presented, and attention will be directed to a number of interesting details. The general dimensions of the Missouri Pacific design, of which ten have been built, are as follows:

SIX-COUPLED PASSENGER LOCOMOTIVE, MISSOURI PACIFIC RAILWAY.

Description.	
Gauge	4 ft. 8½ ins.
Kind of fuel to be used	Bituminous coal
Weight on leading wheels	31,000 lbs.
Weight on driving wheels	120,000 lbs.
Weight on trailing wheels	22,000 lbs.
Weight, total	173,000 lbs.
Weight, tender, loaded	110,000 lbs.
General Dimensions.	
Wheel base, total, of engine	30 ft. 5 ins.
Wheel base, driving	12 ft. 4 ins.
Wheel base, total, engine and tender	55 ft. 1½ ins.
Length over all, engine	44 ft. 8¾ ins.
Length over all, total, engine and tender	67 ft. 9½ ins.
Height, center of boiler above rail	9 ft. 6 ins.
Height, stack above rail	15 ft. 4½ ins.
Heating surface, firebox	152 sq. ft
Heating surface, water tubes	22 sq. ft.
Heating surface, tubes	2,778.5 sq. ft.
Heating surface, total	2,952.5 sq. ft.
Grate Area	42.4 sq. ft.
Wheels and Journals.	
Wheels, leading, number	4
Wheels, leading, diameter	33 ins.
Wheels, driving, number	6
Wheels, driving, diameter	69 ins.
Wheeels, trailing, number	2
Wheels, trailing, diameter	49 ins.
Material of wheel centers	Steel
Type of trailing wheels	Improved radial
Journal leading axles	5½ ins. x 12 ins.
Journal leading axles, wheel fit	5½ ins.

Journal, driving	9 ins. x 12 ins.
Journal, driving, axle wheel fit	8⅞ ins.
Journal, trailing, axle wheel fit	7 ins. x 14 ins.
Journal, trailing, axle wheel fit	7½ ins.

Cylinders.

Cylinder, diameter	20 ins.
Cylinder, stroke	26 ins.
Piston rod, diameter	3⅝ ins.
Main rod, length center to center	111 ins.
Steam ports, length	25½ ins.
Steam ports, width	1⅞ ins.
Exhaust ports, least area	65 sq. ins.
Bridge, width	3 ins.

Valves.

Valves, kind of	Improved piston
Valves, greatest travel	5 5-16 ins.
Valves, steam lap (inside)	1⅛ in.
Valves, exhaust clearance, outside	0
Lead in full gear	0

Boiler.

Boiler, type of	Radial stayed wagon top
Boiler, working pressure	200 lbs.
Boiler, material in barrel	Steel
Boiler, thickness of material in shell	21-32 in., 11-16 in., 9-16 ins, ½ in.
Boiler, thickness in tube sheet	¾ in.
Boiler, diameter of barrel, front	64 3-16 ins.
Boiler, diameter of barrel at throat	69⅜ ins.
Seams, kind of horizontal	Sextuple
Seams, kind of circumferential	Triple
Crown sheet stayed with	Radial stays
Dome, diameter inside	30 ins.

Firebox.

Firebox, type	Wide
Firebox, length	78 ins.
Firebox, width	80 ins.
Firebox, depth, front	77 7-16 ins.
Firebox, depth, back	63 ins.
Firebox, material	Steel
Firebox, thickness of sheet	Crown ⅜ in.; tube ⅝ in.; sides ⅝ in.
Firebox, brick arch	On water tubes
Firebox, mud ring, width	3½ ins. back; 3½ ins. sides; 4 ins. front
Firebox, water space at top	6 ins. back; 6 ins. sides; 6 ins. front
Firebox, grates, kind of	Rocking
Tubes, number of	256
Tubes, material	Charcoal iron
Tubes, outside	2¼ ins.
Tubes, thickness	No. 11 B. W. G.
Tubes, length over tube sheets	18 ft. 6½ ins.

Smoke Box.

Smoke box, diameter, outside	67 ins.
Smoke box, length from tube sheet	69 ins.
Exhaust nozzle, single or double	Single
Exhaust nozzle, variable or permanent	Permanent
Exhaust nozzle, diameter	5 ins., 5⅛ ins., 5¼ ins.
Exhaust nozzle, distance of tip below center of boiler	3½ ins.
Netting, wire or plate	Wire
Netting, size of mesh or perforation	2½ x 2½
Stack, straight or taper	Taper
Stack, least diameter, taper	15 ins.
Stack, greatest diameter, taper	17 ins.
Stack, height above smoke box	37 ins.

Tender.

Type	8-wheel steel frame
Tank, type	Water bottom
Tank, capacity for water	5,000 gals.
Tank, capacity for coal	10 tons
Tank, material	Steel
Tank, thickness of sheets	¼ in.
Type of under frame	Steel channel
Type of trucks	All metal
Type of springs	Double elliptic
Diameter of wheels	33 ins.
Diameter and length of journals	5 ins. x 9 ins.
Distance betweeen centers of journals	5 ft. 1 in.
Diameter of wheel fit on axle	6¾ ins.
Diameter of center of axle	5⅝ ins.
Length of tender over bumper beam	21 ft. 1½ in.
Length of tank inside	19 ft. 6 ins.
Width of tank inside	9 ft. 10 ins.
Height of tank not including collar	5 ft. 1¼ in.
Type of draw gear	M. C. B. coupler

Link pin holes and link slots in M. C. B. couplers have been maintained because of the difficulty of handling cars around very short curves, as in mill yards and upon floats where the water level varies greatly. It is certainly unfortunate that a little inconvenience at a few such points has made it necessary for these weakening elements to be retained generally. The Coupler Committee this year reported an inspection of 400 knuckles of various makes, taken at random from a scrap pile: Of the failures, 37½ per cent. were due to the link pin holes, and 21 per cent. to the link slot, while 12 and 29½ per cent. were due to the tail and knuckle pin hole respectively. The action of the association, after the discussion, which amounted to official approval of omitting the hole and slot, was wise, and in view of the figures of the committee, a great saving of knuckles and consequent break-in-twos may be expected, as a result of such omissions.

A TWENTIETH CENTURY RUN.

133.9 Miles at 69.3 Miles Per Hour.

A continuous run of 133.9 miles in 116 minutes, at the rate of 69.3 miles per hour as an average speed over the entire distance, is truly a "pretty fair run." This was done by the Twentieth Century Limited on the Lake Shore with train No. 25, leaving New York at 2.45 P. M., July 11, leaving Buffalo at 10.50 P. M. of the same day.

On this occasion the Lake Shore had a bad freight wreck near Brocton, N. Y., a short time before the westbound "Limited" was due, completely blocking both tracks. Reference to the tabulated record shows that the train was first delayed at Farnham, and was further blocked at several other points, and did not finally get clear until after leaving Brocton, where the wreck was passed. From there the track was clear and the fast time was made in a remarkable effort to make up the lost time.

This train makes a regular station stop of three minutes at Erie. Another stop is made at Collinwood to change engines, and it is necessary to slow down through Cleveland yard on account of new track work. A regular stop is made at Cleveland, one at Toledo, one at Elkhart, where on the morning in question a dining car was added. There are also two suburban stops in Chicago and several slow-downs for crossings. The following figures were furnished from the official records, and while the times recorded between stations should not be considered as absolutely accurate, the time over each division may be so considered. The weight of the train back of the tender was about 250 tons.

Transcript of run of Train 25, "Twentieth Century Limited," leaving Buffalo July 11, 1902. Eastern Division, 176 miles. Class "J" engine 652, Engineer J. L. Baldwin. Four cars—One composite buffet and baggage, two sleepers, one observation.

Station.	Miles.	Time Passed.			
Buffalo				10.50	On time
B. C. Crossing	2			10.57	
Athol Springs	12			11.06	
Lake View	4			11.12	
Angola	8			11.18	
Farnham	5	A 11.21	D	12.33	Blocked by wreck
Silver Creek	6	A 12.42	D	12.57	Blocked by wreck
Waites Crossing	4			1.02	
Dunkirk	5	A 1.15	D	1.30	Block
Van Buren	4			1.39	
Brocton	5	A 2.12	D	2.14	Passing wreck
Westfield	8			2.24	
Ripley	8			2.34	
North East	8			2.41	
Harbor Creek	7			2.47	
Erie	4	A 2.59	D	3.02	
Dock Junction	2.3			3.07	
Swanville	4.2			3.13	
Girard	7			3.19	
Springfield	4.8			3.23	
Conneaut	7.5			3.28	
Kingsville	7.5			3.35	
Ashtabula	5.7			3.41	
Geneva	9.3			3.50	
Madison	5.4			3.56	
Perry	5.3			4.00	
Painesville	5.5			4.05	
Mentor	6.3			4.10	
Willoughby	4.3			4.15	
Wickliffe	4.2			4.18	
Nottingham	4.7			4.21	
Collinwood	2	A 4.24	D	4.27	Changing engines

Three stops for wreck, one stop for block—176 miles in 227 minutes = 46.5 miles per hour.

Collinwood to Toledo, 115½ miles. Class "F" engine 146, Engineer Jos. Polite, 18 ins. x 24 ins., 10-wheel, 68-in. drivers, 190 lbs. steam, 88,000 lbs. on drivers.

	Station.	Miles.	Time Passed.
Left	Collinwood		4.27 A. M.
Arrived	Cleveland	7.5	4.39
Left	Cleveland		4.41
	West Park	5.9	4.53
	Berea	6.4	4.59
	Olmstead Falls	2.1	5.01
	Shawville	6.2	5.08
	Elyria	4.5	5.11
	North Amherst	0.4	5.18
	Brownhelm	4.4	5.22
	Vermillion	3.2	5.24
	Ceylon	7.5	5.30
	Huron	4.0	5.35
	Sandusky	8.9	5.45
	Venice	2.9	5.47
	Danbury	4.9	5.51
	Gypsum	2.1	
	Port Clinton	3.0	5.55
	La Carne	6.1	6.02
	Oak Harbor	5.5	6.08

Rocky Ridge	3.5	6.11
Graytown	2.3	6.13
Martin	4.5	6.17
Millbury	4.8	6.21
Rockwell Junction	5.0	6.26
Toledo	3.0	6.30

115½ miles in 121 minutes = 57.2 miles per hour.

Air Line Division, Toledo to Elkhart. Class "I" engine 606, 20 x 28 ins., 10-wheeler, 80-in. diameter, 200 lbs. steam, 133,000 lbs. on drivers. Four cars. Engineeer J. H. Caulkins.

Station.	Miles.	Time Passed.		
Toledo		6.32		
West Tower	2.6	6.38		
Holland	7.2	6.44		
Swanton	9.3	6.51		
Delta	5.7	6.56		
Wauseon	7.8	7.03		
Pettisville	4.5	7.07		
Archbald	4.	7.10		
Stryker	6.	7.14		
Bryan	7.3	7.20		
Melbern	5.	7.25		
Edgerton	5.1	7.29		
Butler	6.9	7.35		
Waterloo	7.5	7.42		
Corunna	6.7	7.47		
Kendallville	6.	7.53		
Brimfield	7.	7.59		
Wawaka	4.4	8.02		
Ligonier	5.5	8.06		
Millersburg	7.	8.12		
Goshen	7.7	8.18		
East Yard, Elkhart	10.3	8.27		
Elkhart	.4	A 8.28	D 8.33	Changing engines

133.9 miles in 116 minutes = 69.3 miles per hour.

Western Division, Elkhart to Chicago, 101.1 miles. Class "I" engine 607, 20 x 28 ins, 10-wheel, 80-in. drivers, 200 lbs. steam, 133,000 lbs. on drivers. Five cars, diner added at Elkhart. Engineer J. R. Valance.

Station.	Miles.		Time Passed.
Elkhart			D 8.33
Osceola	5.54		8.40
Mishawaka	5.68		8.46
South Bend	3.98		8.49
I. I. & I. Crossing	1.		8.51
Warren	5.96		8.57
Terrecoupee	4.74		9.02
New Carlisle	1.70		9.03
Rolling Prairie	6.30		9.10
L. E. & W. Crossing	6.05		9.16
LaPorte	1.		9.17
Durham	6.38		9.23
Otis	3.54		9.27
Burdick	3.64		9.31
Chesterton	4.09		9.35
Dune Park	5.65		9.40
Millers	5.80		9.45
Pine	6.86		9.51
Brinson	3.67		9.54
Whiting	2.49		9.56
One Hundredth Street	3.54		10.00
South Chicago	1.11		10.01
Grand Crossing	3.21	A 10.05	10.06
Englewood	2.39	A 10.09	D 10.10
Chicago	6.55		A 10.21

Two suburban stops—101.1 miles in 106 minutes = 57.2 miles per hour.

The fastest running was made on the Air Line Division, from Toledo to Elkhart, the conditions being specially favorable over that division. The following is a summary of the four division runs:

Eastern Division.

176 miles in 227 minutes, 46.5 m. p. h., deducting three stops for wreck and one for block signal.

Cleveland Division.

115.5 miles in 121 minutes, 57.2 m. p. h.

One stop at Collinwood and one at Cleveland.

Air Line Division.

133.9 miles in 116 minutes, 69.3 m. p. h.

No intermediate stops.

Western Division.

101.1 miles in 106 minutes, 57.2 m. p. h.

Two suburban stops in Chicago.

Whole distance 526.5 miles in 570 minutes, 55.4 miles per hour.

The Eastern Division locomotive was the "Class J," Prairie type, illustrated in this journal in March, 1901. The one making the phenomenal run on the Air Line Division was one of the 10-wheel type, designed by Mr. W. H. Marshall, now general superintendent of the road, and built in 1899 at the Brooks Locomotive Works. A description will be found on page 343 of our November number 1899. This is a narrow firebox engine, and it is noteworthy that its record was so much better than that of the new Prairie type. The engines, however, were not selected for this emergency, and probably the conditions were not favorable to this particular Prairie type engine. The run on the Western Division was also made with one of the earlier 10-wheel engines. The section from Collinwood to Toledo was covered by a Class F 10-wheel engine, with 88,000 lbs. on drivers and 68 in. wheels. The record reflects great credit to the motive power department of this road.

In the famous run of October 24, 1895, over this road from Chicago to Buffalo the average speed was 65.07 m. p. h. over the entire distance, with special preparation. In the run recorded here, however, the train was a regular one, and it appears to indicate the possibility of faster regular long distance trains than have ever before been attempted.

FLEXIBLE AND COMMON STAYBOLTS COMPARED.

There can be no doubt of the success of "flexible" staybolts. Where they are tried experimentally their use continues and the number of roads using them seems to be increasing. Comparative figures of cost between the usual form and ball-and-socket-headed bolts are rare and difficult to obtain, because the service of the engines, the shape of the fireboxes and the locations of the flexible stays influence the results. It appears to be proven that ball-and-socket-headed staybolts do not break, and if they relieve apprehension of exploding boilers and tend to increase the life of side sheets, considerable increased first cost is justified. Judging, however, from the figures quoted by Mr. T. A. Lawes, superintendent of motive power of the Chicago & Eastern Illinois Railroad, at Saratoga in June, the actual expense of application of a large number of flexible stays is returned by the saving in repair expense. Mr. Lawes has kindly supplied a copy of his remarks, which are as follows:

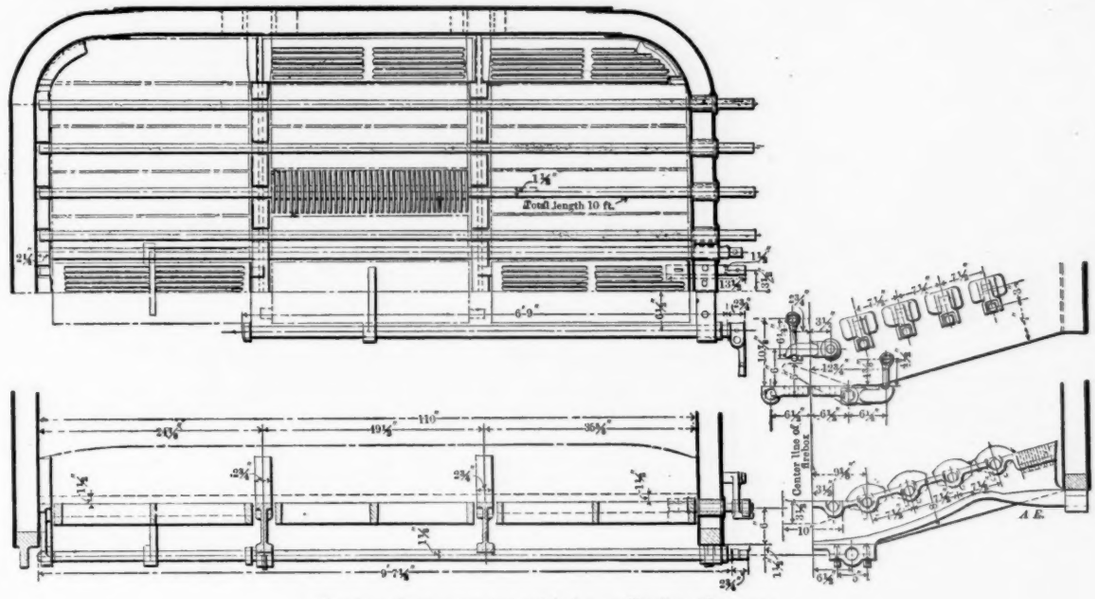
"The cost of renewing 105 staybolts, in lots of six at a time, in one year on a certain engine carrying 200 pounds of steam was $113.40. This includes taking down and putting up the parts of the engine which were in the way of the boiler makers; it also includes the cost of blowing off the engine, letting water out of boiler and filling same, and cost of the water. The cost of the same number of flexible staybolts, put in all at one time, when the engine was in the shop for repairs, was $94.50, no charge being made for stripping, as flexible staybolts were applied when new sheets were put in. From this it appears that the cost of flexible staybolts for the first year's service is $18.90 less than the same number of common staybolts. Now, if the same number of common staybolts were to break the second year, we would save $113.40. However, since the side sheets of our engines carrying 200 pounds of steam last but two years, flexible staybolts are renewed with the side sheets, except that the brass sleeves and caps are used again with the new staybolts. So far as first cost is concerned, flexible staybolts are cheaper than common staybolts when common staybolts are renewed in the roundhouse in lots of six at a time..

"The great advantage in the use of flexible staybolts is that the service of the engine is increased, since they do not break and engines are not held for renewals of bolts. It is our rule to take out staybolts where six adjacent staybolts are broken. The loss of service of our engines in one year under this rule, taking out 105 staybolts and renewing them, amounts to twelve days. In addition to labor and material this period also includes the time it takes to blow off steam, letting out water and cooling off boiler, so that men can work in it; also filling up the boiler, but not getting up steam. It may be of interest to state that the greatest number of flexible staybolts we have used in one engine is 430; the least is 140. We have 27 engines equipped with these bolts—in all 5,280 flexible staybolts in use.

"We use the flexible staybolt invented by Wehrenfennig, chief engineer of material of the Northeastern Railway of

of the railways of India, and still further improved by the Pennsylvania Railroad. No doubt you are all familiar with this flexible staybolt, as it is used in great numbers by that company. The patents on this type of flexible staybolts have long since run out and they can be used by any one without royalty."

Readers will find a description of the Wehrenfennig staybolt in the October, 1900, number of this journal, page 320.

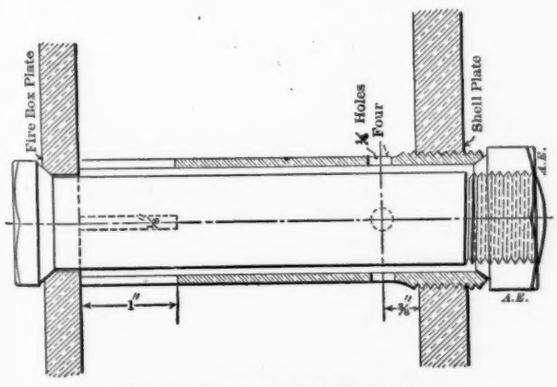


Firebox Arrangement with Long Radius Corners.

FLEXIBLE STAYBOLTS AND LARGE RADIUS FIREBOX CORNERS FOR PREVENTING BREAKAGES.

Philadelphia & Reading Railway.

Mr. S. F. Prince, Jr., superintendent of motive power and rolling equipment of the Philadelphia & Reading, has given the subject of staybolts special attention. The accompanying engravings illustrate a form of staybolt designed and patented by him and also a method of constructing fireboxes with corners of large radius. Both have been applied to locomotives, but not to the same engine.



Flexible Staybolt with Ball Joints.

This staybolt forms a ball joint in a spherical seat in the firebox sheet and a similar joint is made between the nut at the other end and a tube which surrounds the staybolt. This tube bears against the firebox sheet and is threaded into the outer sheet. It serves as a spacer for the sheets and when the nut at the outer end is brought up at the proper tension the bearing of the nut tends to spread the threaded end of the tube and increase its tightness in the sheet. It is not intended that the inner end of the tube shall have a perfect bearing at the inside sheet; in fact, circulation of water around the staybolt is provided for by the slots and by four ¼ in. holes near the other end of the tube. An engine fitted with these staybolts ran for 19 months before coming to the shop for general repairs, and the service of the bolts was eminently satisfactory with none broken. These bolts do not appear to require hammer inspection, as any failure will indicate itself, and as they are in tension only, they may be made of ordinary iron and give satisfactory results.

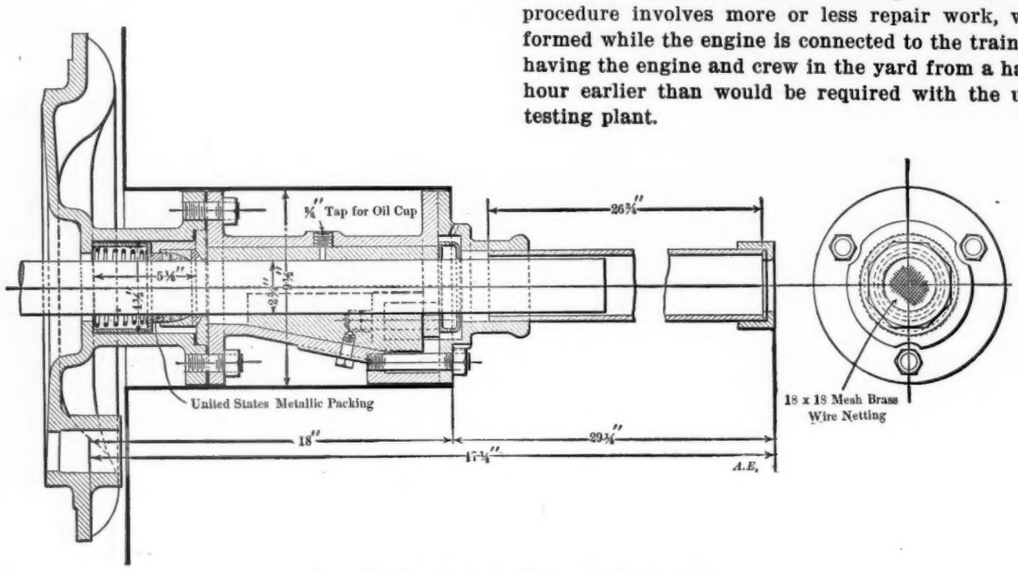
The large radius for the corners of fireboxes seems to be equally promising. Its primary object was to secure construction which would permit of making the corners absolutely tight and incidentally to ascertain the effect upon staybolt breakage. It is a matter of observation that vertical boilers with cylindrical fireboxes seldom break their staybolts. Except after very long service it is seldom if ever necessary to renew staybolts in cylindrical fireboxes, and it was thought advisable to ascertain the effect of the large corners on locomotives. This construction has been in use on a locomotive for over a year. When overhauled for general repairs no broken bolts were found. This engine has a wide firebox and there was no difficulty in using a radius of 12 ins. for the inside sheets. Incidentally this drawing illustrates the construction of the grates and their slope toward the center of the firebox.

One of the best long distance runs ever made by the Pennsylvania Railroad, says the Pittsburgh *Post*, took place July 7 with train No. 11, the St. Louis fast mail. The Pittsburgh division, from Altoona to Pittsburgh, a distance of 117 miles, was covered in 125 minutes, including a delay of 19 minutes, the train consisting of three cars hauled by one of the new E-2 type engines. The train left Altoona 13 minutes late and lost 19 minutes more by unavoidable delays en route, but still arrived at the Union Station in Pittsburgh on time. This is remarkable running, as the Pittsburgh division is the most difficult section of the Pennsylvania's main line.

ADJUSTABLE BEARING FOR EXTENDED PISTON RODS.

Difficulties in taking up the wear of bushings for extended piston rods have led many to discard the practice of using the rods. Mr. V. Z. Caracristi, chief draughtsman of the Intercolonial Railway of Canada, has sent drawings of an arrangement devised by him while connected with the Chicago & Alton and used on locomotives of that road. The piston rod has metallic packing at the front cylinder head. The weight of the rod rests upon an adjustable bearing, which may be secured in the desired position on the inclined plane of the sleeve shown in the drawing. A casing of pipe is used to protect the rod.

The object of the design was to provide means for adjustment without taking off the cylinder head and to avoid the inconvenience of pushing out the bushing with hydraulic pressure. With an easily operated adjusting device, which may be changed in the roundhouse, the rods may be kept up to their proper position instead of wearing perhaps 5-16 in. before being touched, which renders the extension rod valueless. By the use of the metallic packing the cylinder clearance is not increased by the volume of the pipe. This device has been in service about six months, and appears to be giving good results.



Adjustable Bearing for Extended Piston Rods.

Work is now well under way upon the foundations of the new shops of the Great Northern at St. Paul, Minn., and it is expected that the machine shop will be ready for the heavy machinery within a few months. The machine shop is to be 600 x 450 ft., and the boiler and blacksmith shop, which is also well under way, will be 430 x 230 ft. A power plant is to be built, occupying a brick building of 105 x 100 ft., which will supply compressed air and electric current for power, and also furnish electric lighting. We understand that the buildings alone will cost about $1,000,000.

A steam railroad 40 miles long, the Cincinnati, Georgetown & Portsmouth Railway, is soon to be converted from steam to electric traction. The system to be used is the combined system of alternating current for the transmission and rotary convertors for direct current distribution to the line. The Westinghouse Electric and Manufacturing Company is furnishing two 600-kilowatt alternating-current generators and a number of 300-kilowatt rotary convertors to the Tennis Railway Equipment Company, who have the contract for the change.

YARD TESTING PLANTS.

Mr. H. F. Ball, Superintendent Motive Power of the Lake Shore & Michigan Southern, presented the following, in a discussion before the M. C. B. Association, on "Yard Testing and Charging Plants:"

"Is there any economy in fitting up yards with air pipes for the purpose of testing and charging train pipes before the engine is connected to its train? The answer to this question depends entirely on the character of the yard and the trains involved and the method of handling same.

"As a general proposition, all division terminal yards should have air pipes, also yards at large interchange points, and the installation of the air plant will not only be found necessary but economical. At terminals where trains are made up the air brake equipment should be inspected and tested. This procedure involves more or less repair work, which, if performed while the engine is connected to the train, would mean having the engine and crew in the yard from a half hour to an hour earlier than would be required with the use of a yard testing plant.

"The average time required for inspecting, testing and repairing air brakes per train at one of our terminals for a period covering 100 trains was 42 minutes. As some of the trains were made up at times on two tracks, due to yard conditions, a much greater length of time would have been required if the road engine had been used in place of the yard plant.

"From this it will appear that for yards where trains are made up of cars received from connecting lines and local points or where through trains are switched and filled out there is economy in having a testing plant.

"At intermediate division terminals, it is a question whether any advantage would be gained in connecting up the yard plant to through trains which go through solid and which have passed through a regular inspection at the terminal.

"About seven minutes are consumed from the time the road engine is coupled onto the train until it is ready to leave, providing the train is left charged. If the outgoing engine is at hand it would appear that no time would be gained by connecting to the yard plant. The train having previously been inspected, tested and repaired, very little work should be required.

"As a matter of fact very few trains pass through a division terminal yard without requiring some changes in their make-up, and such being the case the yard testing plant will be found necessary and economical in being able to minimize the time required for the air brake work.

"On the road with which the speaker is connected under present conditions very few if any trains are run solid from terminal to terminal. A fast through train may leave Buffalo

for Chicago filled out with Cleveland cars. At Cleveland cars are put in to replace those taken out, and this may be repeated at each division terminal. So in order to reduce the time at division terminals the cars awaiting the trains should be tested and put in good shape before the arrival of the train in which they are to be placed.

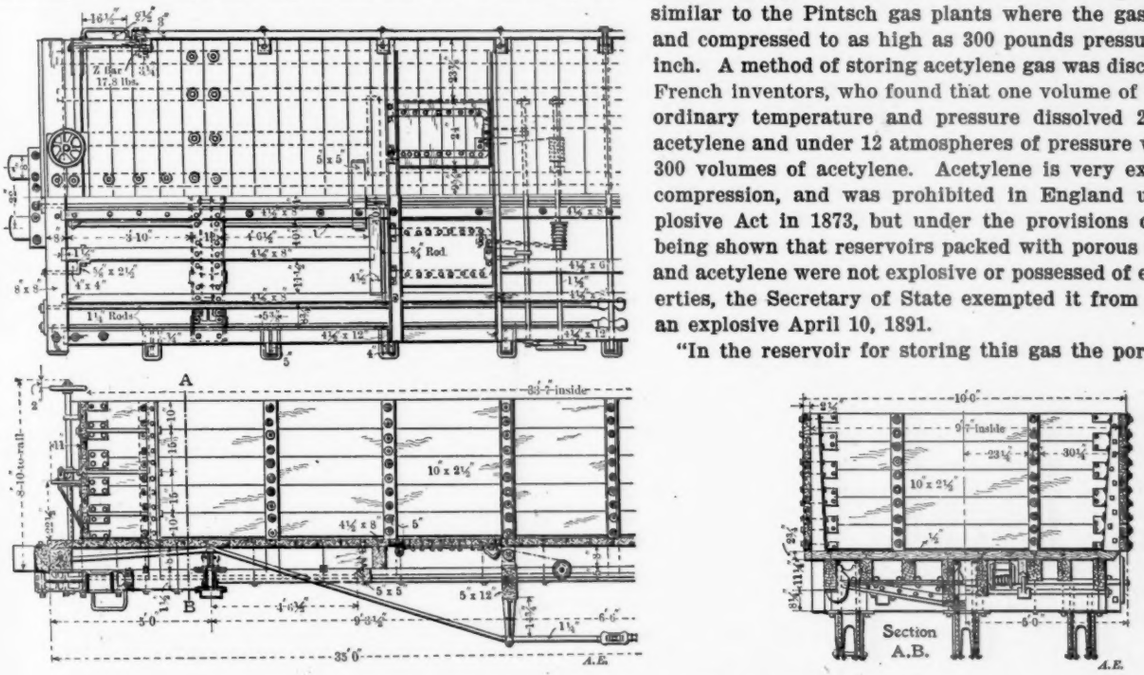
"At points where no yard testing plant is in operation about 20 minutes is required for changing and trying the air after changing engines.

"This time could, no doubt, be reduced in many cases by supplementing the work of charging the train by connecting to the yard plants."

METHOD OF INCREASING CAPACITY OF 40-TON GONDOLA CARS.

Pittsburgh Coal Company.

Mr. J. E. Simons, superintendent of rolling stock and machinery of the Pittsburgh Coal Company, has kindly sent us drawings of coal cars recently constructed for that road, em-



Increasing Capacity of 40-Ton Gondola Cars.—Pittsburg Coal Co.

bodying an ingenious method of increasing the cubical capacity without adding materially to the dead weight. At the brake end the side planks are cut off at the first stake and are set in a sufficient distance to accommodate the hand holds without projecting beyond the outer faces of the rest of the siding. At the first stake a joint is made by means of a vertical 5-in. Z-bar and the rest of the siding is secured to the outside faces of the stakes, as is clearly indicated in the drawings. In this way the width of the car is made 6 ins. greater all along except at the brake end. These cars have sides 50½ ins. high. Mr. Simons says that some difficulty has already been experienced because of overloading, some of the loads put on at the mines being from 90,000 to 94,000 lbs. of bituminous coal, the nominal capacity being 40 tons. This car measures 10 ft. in width outside the box. Those of the Hocking Valley Railway illustrated in our January, 1900, issue, page 5, having the siding outside of the stakes, measure 9 ft. 8½ ins. outside.

There were 800 applicants for admission to the Massachusetts Institute of Technology at the June examination this year and but 400 vacancies.

CAR LIGHTING BY ACETYLENE AND ELECTRICITY.

Progress and the state of the art of car lighting was reviewed by Mr. L. T. Canfield, master car builder of the Delaware, Lackawanna & Western, before the M. C. B. Association at Saratoga. His remarks on acetylene and electric lighting are interesting, and are reprinted in part below:

"The introduction of the Pintsch light advanced the efficiency of car lighting to such an extent that there is not the same chance for improvement over the Pintsch as there was between the oil lamp and the Pintsch. However, the desire of the successful railroad manager and owner to make their passenger cars as comfortable and as pleasant as they possibly can for their patrons, forces them to be on the lookout for any improvements that are not so marked. The success of the passenger business depends to a very great extent upon the car equipment. * * * "

With reference to acetylene, Mr. Canfield said:

"We have several different systems of furnishing acetylene gas for car lighting, some of which generate the gas from a generator applied to each car, others have a generating plant similar to the Pintsch gas plants where the gas is generated and compressed to as high as 300 pounds pressure per square inch. A method of storing acetylene gas was discovered by two French inventors, who found that one volume of acetone under ordinary temperature and pressure dissolved 25 volumes of acetylene and under 12 atmospheres of pressure would dissolve 300 volumes of acetylene. Acetylene is very explosive under compression, and was prohibited in England under the Explosive Act in 1873, but under the provisions of said act, it being shown that reservoirs packed with porous brick, acetone and acetylene were not explosive or possessed of explosive properties, the Secretary of State exempted it from being deemed an explosive April 10, 1891.

"In the reservoir for storing this gas the porous bricks, or asbestos, which is sometimes used, is simply for the prevention of explosion. The acetone is for the storing of gas in large quantities in small space, and these two do not enter into the quality or efficiency of the light. The bricks are first made of a mixture of clay and powdered charcoal. The baking of them burns out the charcoal, leaving a porous brick, with which the storage reservoirs are packed. If these bricks were pressed solid closing up the openings made by the burning out of the charcoal, the solid substance would take up 20 per cent. of the space within the reservoir. Forty-three per cent. of the reservoir would be filled with acetone, leaving 37 per cent. of the space for expansion. A reservoir 20 ins. in diameter by 10 ins. long filled as stated above, charged with acetylene gas at 165 pounds pressure per square inch was placed upon a car on the Delaware, Lackawanna & Western having four lamps with three burners each and one lamp with one burner. This gas burned a total of 260 consecutive hours, remaining in service from March 4, 1902, to May 12 of the same year, without recharging. The fact of being able to run the car so long without recharging makes this a very desirable light.

"I have had experience with none of the systems that have

a generator on each car, and from what I can learn of it, I am very much in favor of the system where the gas is generated at a stationary plant, then stored in reservoirs on the cars. There is another system used largely in the Northwest, where the porous brick and acetone is not used, but a large number of reservoirs are used. I am advised that a car with two or three reservoirs has been known to furnish light for cars in a snow blockade for as long as 12 days. To overcome the explosive feature, this system uses fusible seams in tanks and all high pressure pipes under the car are of fusible material, which will fuse at or below 500 degrees. I have had no experience with this system."

In discussing the various electric systems the speaker stated that the axle lighting system was, in his opinion, the best in use. He described the regulators, but did not consider the device he had seen entirely satisfactory. Continuing, he said:

"In operating the axle lighting system, it is necessary to handle same with a great deal of care. The batteries, for instance, must be charged immediately after they are set up, as the plates will rapidly deteriorate if they are left standing uncharged in the diluted sulphuric acid which is used. Again, you must not charge or discharge same too fast for fear of buckling the plates, and when a new battery is placed in service, it is necessary to charge and discharge it several times. If the battery is overcharged or charged or discharged too fast, it has the effect of sulphating the plates, which increases the internal resistance of the battery and also uses up these plates, and destroys the battery much sooner than in ordinary use. I will not attempt to give a detailed description or try to explain the actual working of the electrical apparatus of these two different systems, as it would take up too much time and as in a general way they resemble each other, but will point out a few of the faults showing what we have to contend with in trying to keep the lights burning when required. The dynamo does not become operative until the train has reached a certain speed, about 12 miles per hour, called the critical speed. In suburban service, for instance, if from any cause the batteries are run down, that is, nearly all of the stored electricity in them is used, you will not get the benefit of the dynamo in recharging them or helping to supply the light until the critical speed is reached, and in many cases about or before the time this speed is attained it is necessary to slow down the train for the next stop. Therefore you are not generating any electricity, but your lights are burning all the time and using it continually from the storage battery, consequently you are going deeper and deeper into trouble, on account of the lights growing dimmer and sometimes going out when the train is standing still, or is running below the critical speed. At this time of the year we naturally have very little trouble, but in the winter time, when the days are short, and it is necessary to use the light for a longer period of time, it is different. On through service you will not, of course, have this particular trouble to contend with, but in the operating of this kind of light the belts occasionally jump off of the pulleys or break, the battery becomes defective, the regulators get out of order, the fuse burns out, there is a short circuit, a wire is broken, the armature burns out, the armature shaft breaks, the dynamo runs hot, the commutator is out of order, or something in the system gives out or goes wrong, and the lights become dim or go out altogether; then we are in trouble. At the present stage of electric lighting in railway service it is absolutely necessary to have an auxiliary light at hand to fall back on. I am sure many of us who have had experience with this light would be perfectly satisfied to do away with it on account of the trouble it has caused— but this is an age of progress and there is no doubt but that there will continually be improvements made in electric car lighting. When it is so perfected that it will not require an expense greatly in excess of that necessary to maintain the gas lamp of to-day I am sure it will come into general use. One point I wish to call your attention to is the fact that the dynamo should be hung to the bottom of the car where it would receive the benefits of both elliptic and equalizer springs to relieve it of all the shocks possible. Another thing, a long belt is desirable in preference to a short one on account of allowing the dynamo to adjust itself to the lateral motion of the axle; but it is absolutely necessary to have the perfect belt cover so as to increase the life of the belt.

"I will conclude by reading a statement comparing the cost to our company of each kind of light for one month."

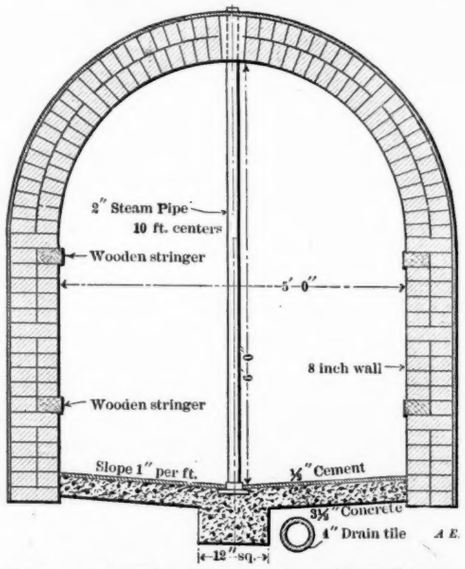
FIRST-CLASS CARS.

Kind of Light.	No. of Lights.	Average Mileage.	Cost per car.	Cost per flame.	Kind of Service.
Oil	6	12,710	$2.40	$0.40	Through
Electric Lights	17	2,092	8.81	.52	Suburban
Electric Lights	36	12,710	37.31	1.04	Through
Electric Lights	25	1,560	7.57	.30	Suburban
Pintsch Gas	20	12,710	5.73	.29	Through
Pintsch Gas	16	2,092	2.45	.15	Suburban

TUNNEL FOR PIPING AND ELECTRIC CABLES.

Iowa State College.

A tunnel 460 ft. long, 5 ft. wide, and 6 ft. high at the center, has been constructed at the Iowa State College at Ames, Iowa, to connect the new Engineering Hall with the central power station. The top is a circular arch of 2 ft. 6 in. radius, both top and sides being of brick, with a ½-in. outside covering of



Piping and Wiring Tunnel.—Iowa State College.

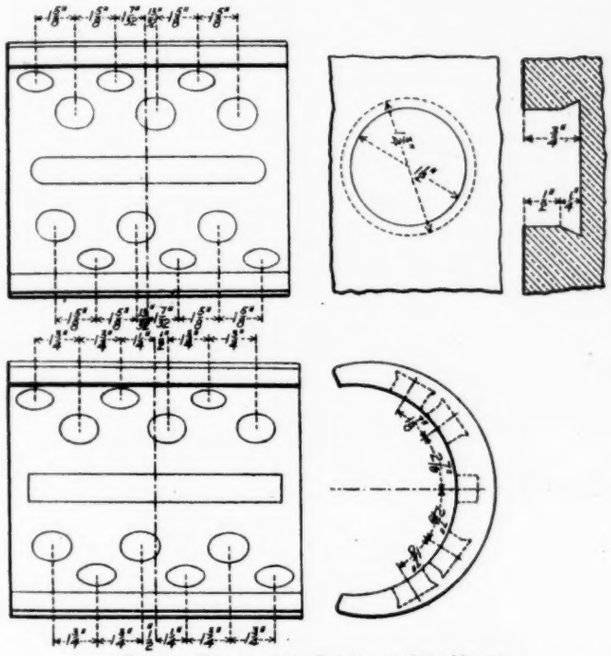
cement and a ½-in. floor of cement on 3½ ins. of concrete. At 10-ft. centers columns of 2-in. pipe are placed along the center of the tunnel, with 12-in. square concrete supports, 9 ins. thick, below the floor of the tunnel. These, passing up through the roof, serve to support brackets forming one end of the carriers for the steam pipes. A 4-in. tile drain extends under the floor of the tunnel.

The heavy pipes will be supported on rollers turning on pieces of 1-in. shafting carried on brackets clamped to the iron columns and to 2 x 4 wooden stringers built into the tunnel walls, as shown in the engraving. This permits of supporting the pipes at any desired grade. The smaller pipes will be supported by ordinary hangers on chains to the shafting already referred to. The portion of the side of the tunnel not occupied by the steam pipes will be used for electric cables and telephone wires. At intervals of 20 ft. the tunnel will be lighted by incandescent lamps. The cost of the tunnel was $3,300, or about $7 per foot. The drawing of the cross section was furnished by Prof. G. W. Bissell, who is in charge of the Mechanical Engineering Department of the college.

SOFT METAL SPOTS IN DRIVING BOXES.

Chicago & Northwestern Railway.

In order to overcome the difficulties due to the heating of locomotive driving boxes, which have become serious because of large locomotive mileage, Mr. Quayle, of the Chicago & Northwestern, has introduced plugs of soft metal in the driving box brasses. These are poured into cavities in the brasses located as indicated in the sketch, and made of such form as to secure them from falling out. These plugs are 80 per cent.



Driving Boxes with Spots of Soft Metal.

lead and 20 per cent. antimony. Bearings of this kind appear to wear the journal somewhat more rapidly than the usual form, but among 950 locomotives the number of hot driving boxes has been reduced to an average of about 26 per month. The holes are "staggered" in such a way as to make the soft metal cover the full length of the journal as it revolves. Two sizes of driving box brasses are shown in the sketch. It is understood that this change has been made general practice on this road with satisfactory results.

A very valuable general instruction car has recently been put into service by the Atchison Topeka & Santa Fe system. A 20-car train air brake equipment, with accessories, and a 6-car train signal equipment are provided, and besides these there is also an up-to-date special equipment, including an "Axle-Light" dynamo and car light controlling apparatus, a Pyle electric headlight equipment, an acetylene gas headlight apparatus, a small model of Vauclain compound cylinders and valve motion, a Nathan cylinder lubricator, a simplex injector and a Crosby muffled safety valve. The car itself is fitted with a Westinghouse friction draft gear and a slack adjuster. The instructor is Mr. J. B. McDonald.

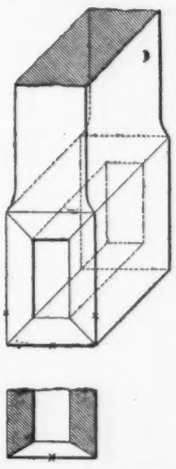
The remarkably fast run of the "Twentieth Century Limited" on the Lake Shore, recorded elsewhere in this issue, suggests the possibility of regular 16-hour trains between New York and Chicago. A speed of 69 miles per hour for 133 miles beats the best record we have for such a distance.

COPPER FIRE-BOX STAYS.

In a paper recently read by Mr. F. W. Webb, Chief Mechanical Engineer of the London & North-Western, before the Institution of Civil Engineers, the superiority of the copper fire-box stay over the copper-alloy stay for use with copper plates was shown by the author's experience upon his four-cylinder compound passenger engines. These engines, of which there are 40 of the earlier class, are the hardest worked on the system, the average speed being 50 miles per hour, and many running on a 158-mile run without a stop, but with a total mileage of 5,622,064 miles the stays renewed were only one per 844 miles (the stays being 1 1-16-in. copper and the boiler pressure 200 lbs. per square inch). The 10 latest engines of this type are making a still better showing. Of the several different alloys of copper with zinc, tin and aluminum that had been tried there had been no improvement over the copper, except perhaps the 9-per cent. zinc alloy; in tests of the alloys the aluminum alloy had been found non-homogeneous, varying greatly in structure from small to large crystals. Riveting over the stay in the copper plate was found by sectioning such a joint to expand the hole and injure the plate, thus making the joint imperfect, so that Mr. Webb concludes that the stay, whatever the material, should be softer than the plate for a good joint.

A TOOL FOR PLANING TIN.

Ordinary planer tools will "run" while cutting tin unless the chip is very light. At the Baldwin Locomotive Works a new tool of the form shown in this engraving was developed for use on locomotive crossheads, which are now generally fitted



Showing Cutting-Edges of Tool.

with tin bearing surfaces. This tool takes a very large chip without the least difficulty, and leaves a good surface. It is easily ground, and not difficult to make. It is made hollow to avoid trouble in hardening. The cutting edges are marked by crosses in the engraving.

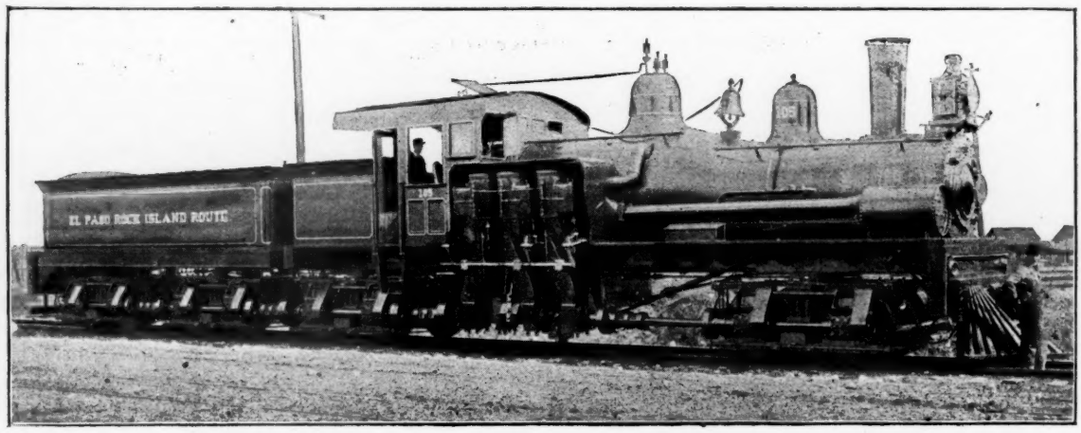
"From what I have seen of the steam turbine, I see a great future before it, and the reciprocating engine has got to look out for itself. Here you have something that you can place almost upon the floor, no matter what its size is. You do not require any particular foundation; the vibration is almost nothing; the room taken is very small, and the economy is about equal to the maximum of other forms of engines now and is likely to be increased."—F. W. Dean, before New England Railroad Club.

A LARGE SHAY-PATENT LOCOMOTIVE.

The El Paso & Rock Island Route.

Heaviest Geared Locomotive Ever Built.

The accompanying engraving is an illustration of a new Shay-patent geared locomotive recently delivered by the Lima Locomotive and Machine Company, Lima, Ohio, to the El Paso & Rock Island Route, which comprises the El Paso & Rock Island, the El Paso & Northeastern, and the Alamogorda & Sacramento Mountain roads, and extends from El Paso, Tex., to Santa Rosa, New Mexico. The road traverses a very mountainous country and has an excessive number of sharp curves and heavy gradients, to which the geared locomotive alone is



Heaviest Geared Locomotive Ever Built.—El Paso & Rock Island Route.

universally adaptable. This locomotive is, in addition to being the heaviest geared locomotive ever built, the heaviest on drivers of any type of locomotive whatever. This is, of course, due to the fact that all of its 16 wheels under both boiler and tender are driving wheels, being driven by the 3-cylinder vertical engine at the side through shafting with universal and slip expansion joints. The total weight (on drivers) is 291,000 lbs., while the greatest weight on drivers of any other locomotive is 237,800 lbs., as exemplified in the decapod tandem-compound locomotive recently built for the Atchison, Topeka & Santa Fe Railroad, and illustrated in our June issue, page 192.

This locomotive is intended for operation on the division of the road laid with 60-lb. rail, extending from Alamogordo, New Mexico, to Cox Canon, a distance of 31 miles, having a total rise between terminals of nearly 6,000 ft., and grades ranging from 3 per cent. to a little over 6½ per cent. There is a stretch of 4.5 to 5.2 per cent. grade for a distance of about 8 miles, including ½ mile of 6 to 6½ per cent. grade, coupled with heavy curves.

A train of 27 cars, each weighing about 16,000 lbs., and a caboose weighing about 12,000 lbs., making total train weight with engine of 362 tons, was hauled over the 6 to 6½ per cent. grade. This haulage is equivalent to 715 tons total weight on level, or 575 tons net train weight on a 3 per cent. grade.

The most important dimensions of this engine are as follows:

SHAY GEARED FREIGHT LOCOMOTIVE.
EL PASO & ROCK ISLAND ROUTE.

Gauge of road	4 ft. 8½ ins.
Fuel used	Soft coal
Weight on drivers in working order	291,000 lbs.
Weight, total, in working order	291,000 lbs.
Weight of tender empty	62,500 lbs.

General Dimensions:

Total wheel base, engine and tender	54 ft. 4 ins.
Total length engine (boiler frame)	44 ft. 5 ins.
Total length engine and tender	71 ft. 9 ins.
Height, center of boiler above rail	7 ft. 7 ins.
Height, top of smokestack above rail	14 ft. 6½ ins.
Height, extreme, over pop valve	14 ft. 10 ins.
Heating surface, tubes	1,837 sq. ft.
Heating surface, firebox	156 sq. ft.
Heating surface, total	1,993 sq. ft.
Grate area	36 sq. ft.
Total tractive force with effective pressure equal to 85 per cent. of boiler pressure	47,000 lbs.

Wheels, Gears, Etc.:

Number of trucks	4
Rigid wheel base of trucks	58 ins.
Number of driving wheels	16
Diameter of driving wheels	40 ins.
Number of teeth in gear rims	41
Number of teeth in pinions	20
Pitch of teeth	2¼ ins.
Face of teeth	7 ins.
Material of gears	Cast steel

Cylinders:

Cylinders, number	3
Cylinders, diameter	15 ins.
Cylinders, stroke	17 ins.
Cylinders, cubic contents of, total	6.9 cu. ft.
Crank shaft, material	Forged steel
Cranks	Set 120 degs. apart

Valves:

Valves, kind	Lima balanced
Valve travel	3¼ ins.
Outside lap	9-16 in.
Inside clearance	1-16 in.
Lead in full gear	1-32 in.
Steam ports	1⅛ x 12 ins.
Exhaust ports	2¼ x 12 ins.
Bridge	15-16 in.

Boiler:

Type	Extended wagon top
Working pressure of boiler	190 lbs.
Diameter barrel at smallest ring	60 ins.
Diameter of dome	30 ins.
Dome connection to boiler	Pressed steel flange 1⅛ ins. thick, with reinforcing plate inside
Thickness of barrel plate	⅝ and ¾ in.
Thickness of tube sheet	½ in.
Horizontal seams	Butt joint, inside and outside welt, sextuple riveted
Circumferential seams	Double riveted

Front End:

Smoke box, diameter	63 ins.
Smoke box, length ahead of tube sheet	62 ins.
Exhaust nozzle, single	Permanent
Exhaust nozzle, diameter	5 ins.
Exhaust nozzle above center of boiler	6 ins.
Smokestack	Taper
Smokestack, least diameter	19 ins.
Wire netting	No. 12 gauge 3½ ins. mesh.

Firebox:

Type	Sloping; radial stay
Length inside	96 ins.
Width inside	54 ins.
Depth at front above grates	60 ins.
Depth at rear above grates	55½ ins.
Thickness sheets, crown	⅜ in.
Thickness sides and door sheet	5-16 ins.
Diameter of crown stays	1⅛ ins.
Diameter stay bolts	1 in.
Water space, front	4 ins.
Water space, sides	3 to 5 ins.
Water space, rear	3 to 4 ins.
Grates, kind of	Rocking
Tubes, number	270
Tubes, outside diameter	2 ins.
Tubes, thickness	No. 12 gauge
Tubes, length over tube sheet	13 ft.

Tender:

Water capacity of tank	6,000 gals.
Coal capacity, coal bunk	9 tons

Special Equipment:

Brakes, engine	Le Chatelier and steam
Brakes, train	Westinghouse air
Sanders	Leach
Injectors	two No. 8 Friedman, non-lifting
Lubricator	Michigan triple sight feed
Blow-off cock	Johnstone
Stay bolts	Johnstone flexible
Pop valves	Crosby
Draw heads	Tower couplers
Lagging	Magnesia

Concrete factory construction was severely tested at Bayonne, N. J., last April, in a fire at the Pacific Coast Borax Company's plant. The fire started from the bursting of an oil main, and was hot enough to fuse cast iron from the machinery and copper from the dynamos and motors. The entire contents of the building were destroyed, but the building, which cost $100,000, was damaged only to the extent of $1,000, a remarkable demonstration of the value of concrete construction. All foundations, footings, walls and columns were of concrete, with twisted, square steel rods imbedded in it. According to an interesting account of the fire in the *Iron Age*, the floors were of 6-in. concrete slabs, supported by 4½ by 21 in. concrete beams, 24 ft. long and spaced 3 ft. apart. The columns are square, of concrete, 17, 19 and 21 ins. respectively. The walls are 16 ins. thick, with 10-in. hollow spaces in the center. The floors were subjected to loads of as much as 1,360 lbs. per sq. ft. under the conditions of continuous service, with various concentrated loads, such as grinding mills, requiring 35 h. p. to operate. In the fire the concrete stood without damage, except from falling tanks from the roof. There was no damage or distortion to any of the walls or columns or injury to the floors, except from the falling tanks. This is a remarkable demonstration of the fire-resisting qualities of concrete.

The possibility of saving $30 per day by the use of a crane over car repair tracks was suggested by Mr. L. H. Turner before the M. C. B. Association in discussing improved facilities for repairing steel cars. A 10-ton crane serving tracks holding 80 cars and having a 90-ft. span would cost $23,000, an investment at 6 per cent. of $3.78 per day. Adding the wages of the operator and two helpers the crane would cost $10 per day. It would not only lift cars or heavy parts, but also transport wheels, truck frames and other heavy material. Mr. Turner estimates the cost of equivalent work done by hand at $40 per day. This saving amounts to $9,000 per year, and the crane would pay for itself and cut off the interest charge in less than three years, and would also reduce the lost time of the cars in the shops. An alert manager of a commercial shop would not hesitate a moment to make an investment of this kind.

The Borsig Locomotive Works, Berlin, Germany, celebrated, on June 21, the achievement of completing their 5,000th locomotive. The festival was attended by many eminent people, and also a workman was present who was in the employ of August Borsig, founder of the works, in 1837, and who is still in the service of the company. The Borsig works were established in the earliest days of railroading in Germany by August Borsig, a self-educated mechanic of great executive ability, and are now being conducted by two of his sons.

The Berlin Military Railroad are about to resume their experiments to determine the maximum possible train speeds, which were interrupted by improvements necessary to their track. Siemens & Halske have recently completed an electric locomotive for them, built to the designs of Chief Engineer Reichel, which it is expected will maintain a higher speed than the previous maximum of 99 miles per hour. This locomotive will take current from the trolley wires at a potential of 10,000 volts without transformation.

CORRESPONDENCE.

VOLUNTARY, LOYAL SUPPORT FROM SUBORDINATES.

To the Editor:

Of all the articles I have read for months, I must say that the one by J. F. Deems in the June number has more real value than anything I have come across. It is characteristic of the man, I believe, though I have met him but once. Many of the contributors of articles would do well to keep out of print for a month and study this one until digested, then apply it. For, in spite of all their pet theories, this man has made a success by considering the rank and file as well as his subordinate officers. His shops turned out work while many others were practically turning out nothing. In these days of trouble, agitation and education, this is the doctrine that counts. Keep up the good work. Such articles are the kind to have in your journal. R.

TREATMENT OF THE SPECIAL APPRENTICE.

A special apprentice's complaint concerning his uncomfortable treatment by his shop mates was printed on page 82 of our March number of the current volume. This has resulted in a surprising correspondence from young technical graduates in all parts of the country. Most of these young men take a very sensible view, and expect to make their way with the shop men by gaining their confidence through merit. The following letter expresses the ideas of a young man who is likely to succeed:

A special apprentice, on entering a shop, at once finds himself an object of interest and possibly suspicion, and will find a little tact and a great deal of hard work necessary to gain the good will and respect of his associates. He must do his work cheerfully, and do his share of it. He must have a good word for everyone, and be always ready to lend a hand. Above all, he must realize that he is there to learn, and not to teach, and the best way to know a thing and learn how to do a thing is to do it. If he is careful about these matters, he will find the men good natured, good hearted and always willing and glad to help him, and if it should ever be his good fortune to be placed in charge of a shop he will understand the men better, and never regret, but be proud of, the time spent among them. F. E. S.

Mr. Walter D. Crosman has resigned as Western representative of the Gold Car Heating Company to become sales manager of the railway department of the Western Roofing and Supply Company, with headquarters at 195 Lake street, Chicago. He will be prepared to supply roofings, linings, and coverings, including 85 per cent. magnesia locomotive lagging; also roofing and insulating materials for cars and all kinds of railroad buildings, pipe coverings, cold water paint and asphalt paint for boiler fronts. Mr. Crosman, from his many years of editorial experience on the *Railway Review* and *Railway Master Mechanic*, has an unusually extensive and valuable acquaintance, and is an important acquisition to the staff of this company.

The twentieth annual convention of the Road Masters and Maintenance of Way Association will be held in Milwaukee September 9, 10 and 11, 1902. The headquarters will be the Plankinton House. Arrangements have been made for an exhibition of articles that will be of interest to the Road Masters and Maintenance of Way Association. There will be ample room for models and devices that are not cumbersome. It is doubtful whether heavy articles can be exhibited to advantage. The convention held a year ago was very successful, and the indications point to a similar condition this year, as Milwaukee is a very popular place. All exhibits should be in Milwaukee not later than Monday morning, September 8, at which time allotments of space will be made by Mr. J. Alexander Brown, secretary and treasurer of the Road and Track Supply Association.

(Established 1832.)

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EDITORIAL ANNOUNCEMENTS.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.* **When a subscriber changes his address** *he ought to notify this office at once, so that the paper may be sent to the proper destination.*

FRICTION DRAFT GEAR.

That progress in locomotive construction, leading up to the enormous weight and power of the present, has not been met by a corresponding increase in the strength of cars is generally admitted. Very little is known of the actual stresses produced by these heavy locomotives, but no less an authority than a committee of the Western Railway Club, of which Mr. W. H. Marshall was chairman, stated that an engine coupling to its train gives stresses ranging from 65,000 to 142,000 lbs.; a switch engine coupling to a dynamometer car standing alone gives 103,000 lbs.; a switch engine coupling to a train of loaded cars may give a stress of 199,000 lbs., and 30 loaded cars moving at 6½ miles an hour coupling to 10 loaded cars with brakes set produced a shock of 376,490 lbs. The committee reports another astonishing case. A loaded 60,000-lb. furniture car was standing on the track and the dynamometer car (the special test car of the Westinghouse Air Brake Company) struck it at a speed of 13½ miles an hour. The apparatus in the car recorded 381,704 lbs., which was its limit. What the actual shock was cannot be told.

This committee was appointed to study the stresses in draft gear in connection with the consideration of the draft gear question. From its report we have a fearlessly expressed opinion with the force of unprejudiced judgment of railroad officers who have themselves conducted the experiments. Our readers should procure the report from this committee and make it a subject of thorough study. The following forcible expression shows the opinion of this committee, and considering its source it is the most important declaration thus far made in connection with the subject:

"From the general results of the tests it is believed that the tensile stresses in draft gears with careful handling will frequently reach 50,000 lbs., with ordinary handling 80,000 lbs., and with decidedly rough handling fully 100,000 lbs., while the buffing stresses can be placed at 100,000, 150,000 and from 200,000 to 300,000 lbs. respectively. In extreme cases the buffing stresses will go considerably above the last named figure. It will undoubtedly require more extensive tests to determine whether these figures need modification, but it is evident that the tests give us a more definite idea of the stresses which draft gears and sills must stand than we have been able to obtain heretofore. Continued investigation along these lines should finally result in a sufficient amount of information to permit of a more exact method in the designing of draft gears.

"We think the figures show the necessity of something better and more effective than the spring draft gear so commonly used. It would be reasonable, in view of the above figures, to require draft gears and underframes to be capable of withstanding tensile stresses of 150,000 lbs., and buffing stresses of 500,000 lbs., and it is evident that the present spring resistance is inadequate. Whatever one may think of the details of the various friction draft gears, it must be evident that in the character and amount of resistance they are superior to the spring gears."

A RAILROAD OFFICER'S CORRESPONDENCE.

In railroad service there is scarcely anything more important to a successful career than the ability to write clearly. The character of a railroad officer's correspondence very largely determines his success, because it is such a vital element in the transaction of his business. Two classes of correspondence are worthy of special attention—that which contains instructions to subordinates and that which goes before the superior officers in the form of reports and recommendations.

In his recent paper before the Western Railway Club, Mr. F. M. Whyte, of the New York Central, said that one of the greatest difficulties in railroad work is to get instructions to the man who does the work. For example, consider the importance of getting orders to train and engine crews, and the correct understanding of the orders. There is also much difficulty in getting back from the man who does the work suitable reports of the results of what he has done. When something out of the ordinary is to be done, the correspondence becomes at once voluminous or the service is put out of order, unless, indeed, the instructions are given by one who has the time to consider carefully the peculiar conditions at each place, and the peculiarities of the men who are being dealt with. A moment's consideration shows how important is the ability to instruct clearly.

One reason for the remarkable development and rapid rise from the ranks of some of the best railroad officers of the day, and one reason why this service is so well supplied with able men, is the fact that they have grown up with their correspondence, and have been obliged to depend upon their ability to state facts clearly in connection with their every-day work. Correspondence in itself is a developer of character and ability, perhaps because it stimulates clear thinking and a judicial method of weighing the importance of things.

In the matter of recommendations, he who states his case clearly and fortifies every point strongly, is likely to be allowed to try that which he recommends. We go so far as to say that the railroad man, whether he is an officer or not, who treats his correspondence with his superiors as if it was some time to be printed and constitute his record for a basis of promotion, will find his advancement rapid.

It was recently the privilege of the writer to watch the effect of a little care in the preparation of a recommendation.

It was made by a young man who had studied his subject thoroughly and wanted to try a radical departure in shop practice which involved a large expenditure. He was quite willing to become responsible for results. His argument was clear, ample, convincing and concise, and it brought consent in the following words: "There must be something in this. You may try it." This same plan, however, had been repeatedly offered before by this young man's predecesors, and had been rejected.

Evidently there is a close relation between a clear, convincing method of expression and success.

APPRENTICESHIP.

Every practicable suggestion made in connection with the apprenticeship problem brings such a response as to indicate a general feeling that it has been somewhat neglected. It is one in which every industry is interested and is a national question. If all of the trades are to be left to "handy men" who have no education and no outlook beyond the present day, the future will bring problems which will be full of difficulty. Anything which may be said or done to bring this fact before the mechanical world should be brought forward immediately, in order to awaken to action all who can be brought to appreciate it.

An officer of one of our best-known machinery building companies has written this journal, urging the publication of the descriptions of good apprentice systems, mentioning that of the Baldwin Locomotive Works (American Engineer, October, 1901, pages 309 and 319), as being specially worthy of record. This gentleman has made a careful research throughout this country into apprenticeship methods, and says that in many instances he finds "shocking conditions." Before learning of the Baldwin plan he had thought his own system the best in use, but now has acknowledged gracefully a superior. This is high praise for the Baldwin system, because the company with which our correspondent is connected has an unequaled reputation for its excellent work and its workmen.

Our correspondent says: "The whole trouble in any of these systems is in carrying them out in the spirit and letter of the way in which they are started. It is hard to keep an apprentice system up to a high standard. If it were not for our apprentices I hardly know how this establishment could be carried on and kept up to the standard of workmanship set by the company many years ago. It is growing harder and harder every day, and without the apprentices trained in our works I think the task would be well-nigh hopeless."

Those who treat the apprentice problem as our correspondent has done have a grievance against those who do not. He says: "We seem to be furnishing help from our drawing room and from our shops to people who appear so indifferent to the work that they do not train men themselves and even take them from us, greatly to our discomfort."

Without doubt the reason for neglecting apprenticeship is that its operation is slow. It requires a look into the future to appreciate its advantages, and men are too often so busy making a record this year that they forget the better record which may be made in a number of years by aid of a thorough apprentice system. One of the greatest needs on railroads to-day is the development of home talent, and apprenticeship is a good starting point.

There is an evident need of elasticity in establishing tonnage rating for locomotives, lest zeal in the direction of the maximum possible weight of trains shall lead to overloading and delay. Mr. Henderson gave a much-needed word of warning against this in his article on page 168 of the June number of this journal. It is well to figure the tonnage rating carefully as a starting point, but the best of judgment and knowledge of the operation of the locomotives is required in loading them so that they will haul the heaviest possible loads without danger of laying out traffic by slow movements or by doubling. Among the factors to be considered is the condition of the boilers and the condition of each engine with reference to steam-making. Foaming often seriously affects the amount of freight which a locomotive will haul, and in general it may be said that the cylinder power does not by any means indicate the capacity to get trains over long grades, simply because, for one of several good reasons, the boiler may not furnish the necessary steam. One effect of recent advances in the loading of locomotives is to throw light upon the insufficient boiler power of the practice of from five to ten years ago. The incapacity of boilers is indicated by the fact that recent tests on a large road show a temperature of smoke-box gases of over 1,200 degrees F. in a large number of cases, while with larger boilers of more recent engines the temperature is but 600 degrees. It would seem to be worth while to place the responsibility for the loading of engines in the hands of men who fully understand the factors which enter into efficient rating, and who are qualified to have an influence in future locomotive designs.

PERSONALS.

Mr. Charles M. Muchnic, mechanical engineer of the Wisconsin Central, has resigned to accept the same position on the Denver & Rio Grande.

Mr. George W. Rink has been appointed chief draughtsman of the motive power department of the Central Railroad of New Jersey, to succeed Mr. W. E. Denton, recently resigned.

Mr. Charles H. Kenison, of Portland, Me., has retired, at his own request, from the office of master car builder of the Maine Central Railroad, after a long term of faithful service, and the car department has been placed under the jurisdiction of Mr. Philip M. Hammett, the superintendent of motive power.

Mr. George S. Hodgins has joined the editorial staff of *Railway and Locomotive Engineering*. He was formerly one of the editors of the *Railroad Digest*, and gained his practical experience in the shop and drawing office of the Canadian Pacific and other important railways. The American Engineer wishes him the best of success in his new work.

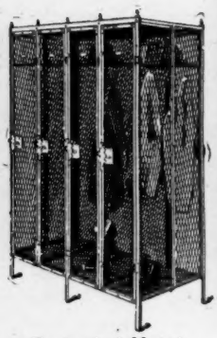
Mr. W. B. Leach, formerly general foreman of the New England division of the New York, New Haven & Hartford Railroad, has been appointed master mechanic of the Albany division of the Boston & Albany. Mr. Leach is a comparatively young man, 32 years of age, having entered the employ of the Boston & Albany as machinist in 1890, upon the completion of his apprenticeship.

It is with regret that we learn of the accidental death of Prof. J. B. Johnson, dean of the College of Engineering of the University of Wisconsin, on June 23, by falling under the wheels of a wagon loaded with household goods being driven to his summer home near Fennville, Mich. Professor Johnson, who was 52 years of age, was for many years professor of civil engineering at Washington University, St. Louis, Mo., and was prominently connected with a great many government tests of timber and other materials. Two years ago he was appointed dean of the College of Engineering at the University of Wisconsin, which position he filled up to the time of his death. He was a member of the American Society of Civil Engineers and the Western Society of Engineers, and through his able contributions to engineering literature and the number of text-books of which he was author he came to be regarded as a leading authority on engineering.

EXPANDED-METAL LOCKERS.

The accompanying illustrations are views of the improved expanded-metal lockers manufactured by Merritt & Co., 1024-8 Ridge avenue, Philadelphia, Pa. The time has come when the provision of a suitable place for employees in shops to leave their belongings while at work is one of the important features of shop equipment. Wooden closets and chests no longer fulfill the requirements of progressive shops, either as to neatness and sanitary qualifications, or in regard to fireproof construction. Wooden lockers are a positive fire risk, especially in view of the liability of oily waste being left in them by the workmen. Furthermore, wooden lockers are dirty and become foul through lack of ventilation, and will breed vermin unless unusual care is taken to prevent it.

The Merritt locker is constructed entirely of metal, of angle iron framing, with the expanded metal webbing in the sides, top and bottom. The expanded metal webbing is formed from high grade sheet steel, which is cut and opened in one operation into diamond-shaped meshes of suitable sizes. Thus there are no joints or connections, each side being formed of a single sheet, and the web cannot be pried open and entered like woven wire.



Expanded-Metal Lockers.

A Modern Locker Room.

The neatness, compactness and entire divisibility of these lockers are well illustrated in the accompanying view of a locker room equipped with Merritt lockers. The cleanliness and sanitary advantages resulting particularly from the perfect ventilation are evident with this arrangement. Also it tends to promote cleanliness among the employees, and practically prohibits the hiding of tools, "pints of whiskey," etc., in the lockers, as is so usual with wooden lockers. The neatness of this system of lockers was strongly evidenced in an illustration of the washroom of the Norwalk Iron Works Co., which was presented in a paper on Locomotive Shops, by Mr. L. R. Pomeroy, before the recent Saratoga Convention of the Master Mechanics' Association. The lockers were shown arranged around the edge of the washroom—a most accessible arrangement.

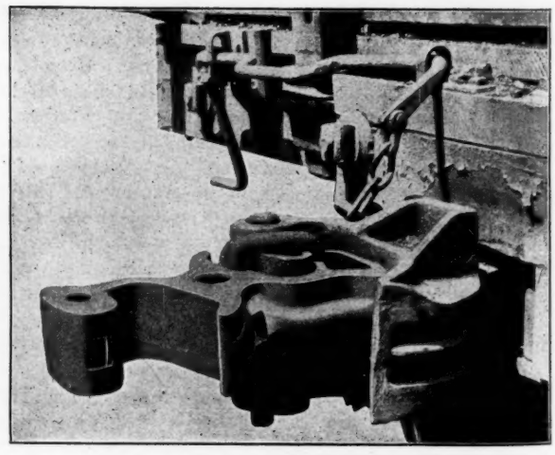
The reduction of repairs with metal lockers is not to be overlooked, as in a certain case with wooden cupboards for 2,500 to 2,800 employees it requires the entire services of one carpenter to keep them in repair. The Merritt metal lockers are strongly advocated by many leading railroads and industrial establishments, and are very highly endorsed by the Fire Underwriters' Association.

The Standard Steel Car Company is equipping its new plant for electric driving throughout. A recent purchase from the Westinghouse Electric and Manufacturing Company comprises two 375-kilowatt alternating-current generators, one 400-kilowatt direct-current generator, and a 300-kilowatt rotary converter for use as a connecting link between the two. This company has purchased also about fifty induction motors, which will be used largely for direct connection to machine tools.

AN AUXILIARY COUPLING FOR AUTOMATIC COUPLERS.

The accompanying engravings illustrate a new auxiliary coupling for automatic couplers, that has recently been brought out by the Railway Appliances Company, No. 675 Old Colony Building, Chicago, Ill. This coupler is adapted for both pushing and pulling on curves too sharp for operation of the M. C. B. standard coupler, and is exciting interest amongst railroad men, due not only to the approaching abolition of the link slot and pin hole, but also to the investigation which has been carried on for some time by the Interstate Commerce Commission regarding the methods used by the railroad companies for handling cars on very sharp curves, such as occur at many factory sidings. At present such sidings are operated with link and pin between the couplers, or by means of coupling bars. This is bad enough as it is, but with the approaching abandonment of the link slots and pin holes it will be necessary to push cars around such curves with a push-pole and haul them out with a chain or rope, which plan is practically prohibited by the fact that pushing is very liable to damage the release rigging, and increase repairs at a point where the greatest number of defects are now developed; also by the danger of throwing cars off centers, as well as the increase of time necessary to set cars.

The Auxiliary Coupling.



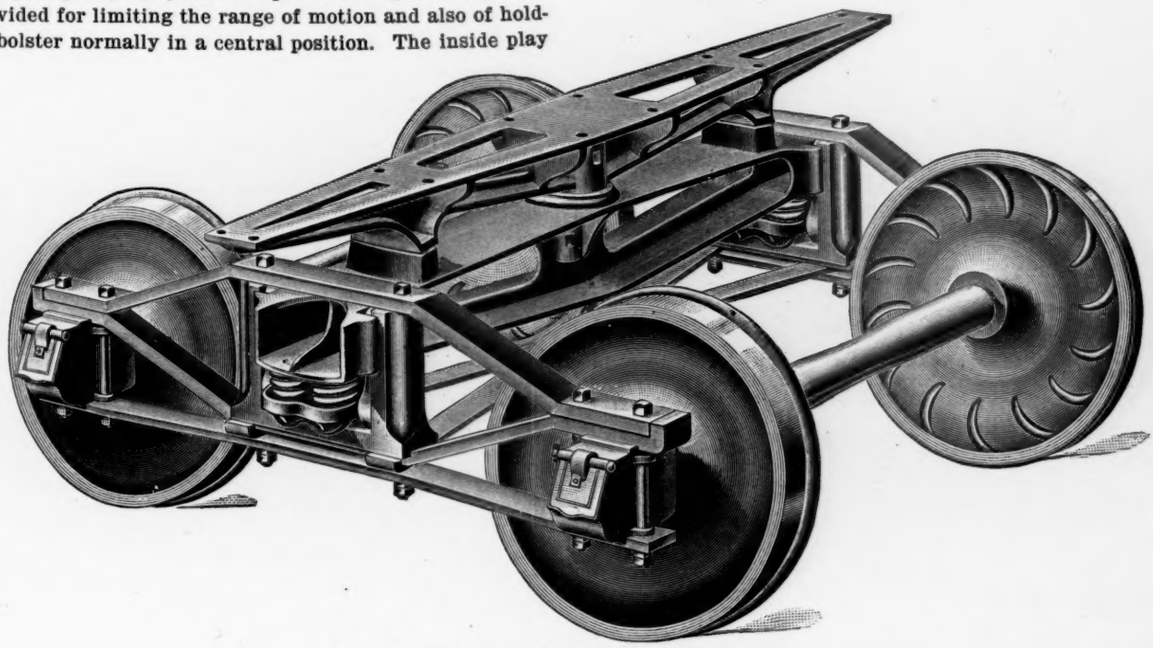
In Place upon the Knuckle of an Automatic Coupler.

After considerable experimenting and study this auxiliary coupling was brought out, patent applied for May 13, 1902. It is cast from open-hearth steel in a single piece and weighs no more than the average knuckle. When a curve is reached on which draw-bars pass, it is taken from the caboose or engine and hung on either one of the couplers, the opposing knuckle being open; the cars are then backed together, and coupling

takes place automatically. The cars can then be hauled to a straight track, and the auxiliary removed or left in position. Two of the largest switching roads in Chicago are using this device and it is on test on many others, its great advantage being that it is automatic and does not require the presence of a switchman between the cars. The lower engraving shows the auxiliary in place upon an automatic coupler, the looped portion at one end supporting it upon the knuckle of the coupler.

THE COMMONWEALTH STEEL TRUCK.

The accompanying engraving is an illustration of the new truck manufactured by the Commonwealth Steel Company, St. Louis, Mo. In this truck side motion of the truck and body bolsters, which is so necessary for the safety of wheel flanges in the large capacity cars, has been provided for, but means are also provided for limiting the range of motion and also of holding the bolster normally in a central position. The inside play



The Commonwealth Swing Motion Steel Truck.

of the bolster is secured by use of a swing spring seat suspended by two links from inside the vertical columns of the side frames, the links being supported by lugs cast integral with the columns. The truck bolster, the ends of which rest on the springs supported by the swing seats, is provided with vertical cast flanges, which limit the side play by their contact with the columns, and the swing spring seat support is also provided with flanges which come into contact with the bottom arch bar, permitting the same amount of lateral or swing movement as the bolster; and as both limiting stops come into contact at the same time, one near the top and the other at the bottom of the side frame, there is no tendency to overturn the side frame. As the links hang normally in a vertical central position it is evident that any side deflection will tend to raise the bolster a small amount, resistance to which will tend to keep the car returned to normal position.

From the method of supporting the spring seat it is free to swing and will therefore always remain parallel to the spring bearing face of the bolster, so that the load will be uniformly sustained and no tendency exerted to cant or cramp the springs. As the faces of the bolster are always horizontal, the pressure on the springs will always be vertical in direction regardless of the amount of side swing. This form of construction lends itself readily to the use of sufficient metal to secure an ample factor of safety in the suspension parts. However, if breakage of a link or lug should occur, the result will be simply a transformation to a non-swinging truck and there would not be enough drop of the bolster to produce injury from running.

The cast steel truck bolster, which is patented, is notable for its great strength with the light weight and absence of rivets and bolts. The design is varied somewhat in the different capacity cars, a deeper web being used in those intended for heavier loads. The body bolster is of similar construction, also made of cast steel, and is light in weight for its strength.

KEYSTONE "CROCODILE" WRENCHES.

"Crocodile" wrenches, as every man with shop experience knows, are most convenient tools for many purposes, particularly in locomotive and car work. The difficulty has been to get good ones. The Keystone Drop Forge Works, of Philadelphia, who make the "Keystone" connecting link and other drop forgings so largely used on the car equipment of leading railroads, are making excellent wrenches, bearing their well-known trade mark, which is found only on good product, this company

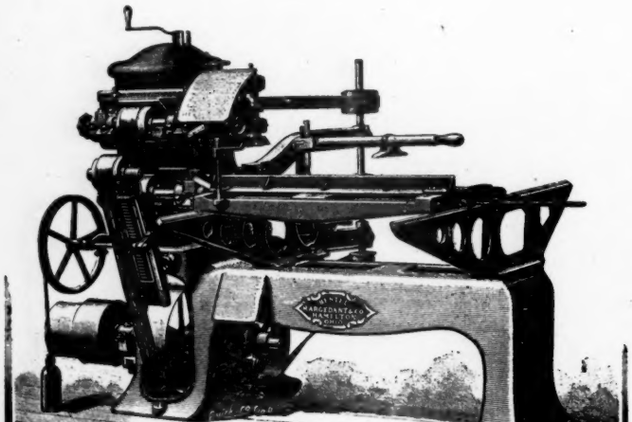
Keystone Crocodile Wrenches.

not being willing to jeopardize the high esteem in which it is held by anything but the best material and workmanship. Wrenches made of steel in which the carbon and other ingredients are not uniformly distributed are not satisfactory because the teeth are too hard or too soft in spots and will crush or flake off. All of the wrenches of these manufacturers

are of a special grade of pipe wrench steel such as is used in the famous "Stillson" wrenches. The handles are designed with a flute and are set so that the fingers readily grip the wrench with a good broad surface on the edge for the hand. All sizes are drop-forged from the solid bar without welds or inserted jaws. These cost no more than those of inferior quality. The connecting links made by this firm are so satisfactory as to justify confidence in other products of their works. The accompanying illustrations show three forms of "Crocodile" wrenches. A representative of this journal has made a careful investigation of this product. The address of the Keystone Drop Forge Works is Twentieth and Clearfield streets, Germantown Junction, Philadelphia.

SOLID-FRAME TENONING MACHINE.

The accompanying engraving is a view of the improved solid-frame tenoning machine, with roller carriage tables, manufactured by the Bentel & Margedant Company, Hamilton, Ohio. This tenoner is adapted for both heavy and light work, cutting single-length tenons up to 3½ ins. in length, and double-length tenons up to 6½ ins. in length. The machine frame is cast with the cutter-head column and table brackets in one single piece, so that the sliding table and cutter-heads retain under all circumstances their relative adjustment and



Improved Solid-Frame Tenoning Machine

cannot get out of line. This form of frame secures also a positive firmness and total absence of quiver, so that very smooth tenons can be produced on heavy or light material. The cutter-head column is arranged on the face with heavy dovetail slides, upon which the two cutter-head housings rest. The dovetail slides have adjustable gibs, so that any looseness in the sliding surfaces which may be caused by natural wear can be taken up. The adjustment facilities of the two horizontal housings on the column are as follows: Both housings can be raised and lowered, each one independent, or both can be raised and lowered together, keeping the adjustment or relative setting of the two unchanged while raising or lowering. The upper housing is provided also with horizontal slideways, so that it can be moved sideways or horizontally for adjusting of shoulder or oversetting the shoulders. The vertical adjustment is made by the crank shown on top of the machine, and the movement of a single housing or of both housings together requires only the throwing of a small lever in or out of gear, while turning the crank. Also, attention is called to the sliding or carriage table, which is arranged with roller and "V" slides for easy and accurate movement. This will be highly appreciated by all who use such machines, as also the fact that the slides are of such length as to permit the cutting of tenons 24 ins. wide and 3½ ins. long with single heads, or 24 ins. wide and 6½ ins. long with double cutter-heads, or 8 ins. long and 24 ins. wide by cutting twice. The cope cutter-heads are attached to the housings of the horizontal cutter-heads by means of slides, permitting them to be moved either with the horizontal heads or independent of them, both vertically and laterally, for adjustment in coping. They are driven by a counter-shaft attached vertically, placed at a considerable distance from the heads in order to run long belts, and in such a position that the driving belts retain the necessary tension in all positions. The table is provided with a gauge of all lengths, and with an adjustable fence for either square or angular tenons, and has a convenient lever for holding the material down.

The various systems of car lighting were compared by Mr. Canfield at the Saratoga convention, and the result of the discussion was to place this among the subjects for investigation and report next year. Elsewhere in this issue will be found an abstract of Mr. Canfield's remarks, including comparative figures of cost of various systems on the Lackawanna. By reference to the table, which, for convenience, is repeated here, the costs may be studied. If these figures represent comparable lighting service, and it is assumed that they do, Pintsch gas on their suburban cars costs only five cents per month more than oil in their through car service, and electric lighting costs about seven times as much as gas on through cars. As the cost is an important factor in such comparisons, it is well that the whole subject should come before the M. C. B. Association. The figures are as follows:

	First-Class Cars.				
Kind of Light.	No. of Lights.	Average Mileage.	Cost per Car.	Cost per Flame.	Kind of Service.
Oil	6	12,710	$2.40	$0.40	Through
Electric lights	17	2,092	8.81	.52	Suburban
Electric lights	36	12,710	37.31	1.04	Through
Electric lights	25	1,560	7.57	.30	Suburban
Pintsch gas	20	12,710	5.73	.29	Through
Pintsch gas	16	2,092	2.45	.15	Suburban

The Chicago Pneumatic Tool Company, Chicago, Ill., has, through its counsel, John R. Bennett, of New York City, commenced suit in the U. S. Circuit Court against the Philadelphia Pneumatic Tool Company and others, for an injunction to enjoin the Philadelphia company from further manufacture and sale of pneumatic tools. It is alleged that the patent regarding which the suit has been brought has been sustained by the U. S. Courts, and that the tools now being manufactured by the Philadelphia company are precisely the same as those against which the courts have already granted injunctions. Injunctions have been granted against several infringing manufacturers, the last having been against the Standard Pneumatic Tool Company, of Chicago, which resulted in that company conveying its plants and business to the Chicago Pneumatic Tool Company in settlement. Under its patents, the Chicago Pneumatic Tool Company claims the exclusive right to all pneumatic tools now on the market.

The Haydon & Derby Manufacturing Company, 85 Liberty street, New York City, are advised that the Metropolitan 1898 injector, model "O," has been adopted by the Philippine Insular Government as the standard on their Class "A" cruisers, fifteen of which have been thus fitted, as a result of a contract secured by F. W. Horn & Co., Yokohama, Japan, agents for the Haydon & Derby Manufacturing Company at that point, after careful and exhaustive tests made with a view of selecting devices which had the greatest merit. The adoption of the Metropolitan injectors under such conditions endorses their superiority.

The Steubenville and Wheeling Traction Company has just purchased two 500-kilowatt Westinghouse railway generators, to be used in the operation of an electric railroad running from Steubenville, Ohio, to Wheeling, W. Va., and also a line from Wellsburg to Wheeling.

In an order for 500 cars recently placed at the Middletown Car Works by the Norfolk & Western Railway the brake-beams specified are the Damascus brake-beam, manufactured by the Damascus Brake Beam Company, St. Louis, Mo.

DETERMINATION OF THE POWER REQUIRED TO OPERATE THE TRAINS OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD AND THE RELATIVE COST OF OPERATION BY STEAM AND ELECTRICITY.*

By Bion J. Arnold.

In August, 1901, the writer was commissioned by the New York Central Railroad Company to study the conditions governing the operation of its trains between Mott Haven Junction and Grand Central Station, and to report upon the feasibility of operating them by electricity. This division consists of 5.3 miles of four-track road forming the trunk line, or main artery over which the trains from the three divisions of the New York Central and the main line of the New York, New Haven & Hartford Railroads enter the city of New York. For 2.58 miles from Mott Haven Junction the tracks are carried on an elevated stone and steel structure; then for 2.04 miles through a tunnel underneath the street, emerging into an open cut .68 of a mile long, then terminating at the Grand Central Station in an intricate stub-end yard, having about eight miles of switching tracks. Over this division are made nearly 600 train movements per day, as almost all trains entering the yard or station must be returned to Mott Haven Junction, owing to lack of sufficient storage tracks at the Grand Central terminus.

Soon after taking up the work it became evident, on account of the number and weights of the trains to be handled and the numerous variable elements entering into the operating system, which would not adapt themselves conveniently to formulæ, that the most practical and satisfactory way of ascertaining the power required to propel the trains was to measure, by means of a dynamometer car, the "draw-bar pull" of a sufficient number of trains of various weights, to determine the average power required per train and from this compute the general load diagram.

A dynamometer car known as "Test Car No. 17," owned jointly by the Illinois Central Railway Company and the University of Illinois, was secured, and men thoroughly skilled in its use were employed to operate it. This car was coupled between the locomotive and the train in each case, and operated on trains running over the different divisions of the road, so that not less than four runs, two or more in each division, were made for each class of train. Since the trains of all divisions, including those of the New York, New Haven & Hartford Railroad, run over the New York Central tracks between Mott Haven Junction and Grand Central Station, the records of the New York Central trains for this division will apply to trains of equal weight on the New York, New Haven & Hartford road, and were so considered in the calculations.

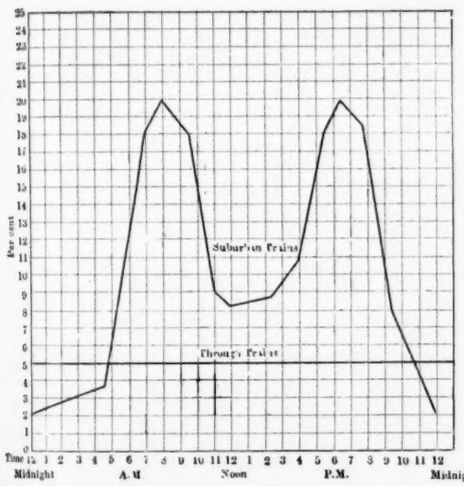
(This dynamometer car was illustrated and described in detail in our August, 1900, issue, page 239.)

Dynamometer records were taken on eight different classes of trains which are in daily operation over some of the divisions of the road. In each record was recorded graphically the following:

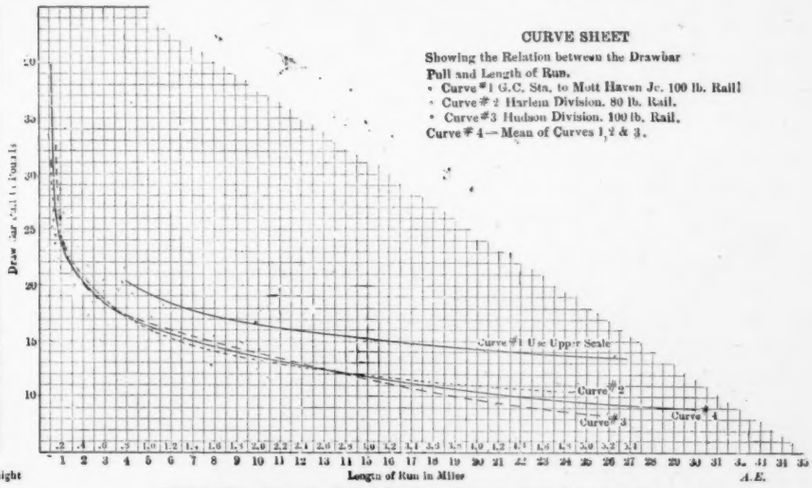
(1) The "draw-bar pull" of train.
(2) The speed of the train, and—
(3) The profile of the road, at the bottom, and the alignment, at the top of each record, so that it is possible to calculate by formulæ the theoretical horse power required to haul the train under the conditions of each case, and after equating for grade and curvature, to check the result by the curves.

The records did not include the power required to propel the locomotive, nor the head end resistance offered to it by the air, and also when the dynamometer car was running backward, the power to propel it was not represented in the record and its weight should not be taken into consideration as a part of the train. These factors were taken into account when determining the final load diagram.

*Abstract of paper read before the June convention of the American Institute of Electrical Engineers at Great Barrington, Mass.



Ratio of Weight of Live Load to Light Weight of Train.


CURVE SHEET
Showing the Relation between the Drawbar Pull and Length of Run.
Curve #1 G.C. Sta. to Mott Haven Jc. 100 lb. Rail
Curve #2 Harlem Division. 80 lb. Rail.
Curve #3 Hudson Division. 100 lb. Rail.
Curve #4 — Mean of Curves 1, 2 & 3.
Draw-bar Pull in Pounds
Curve #1 Use Upper Scale
Curve #2
Curve #3
Curve #4
Length of Run in Miles
A.E.

Draw-Bar Pull in Pounds per Ton of Train Weight—not tractive effort.

Method of Obtaining Horse Power at Draw-Bar From Dynamometer Records.

This was obtained in general in the following manner: From actual dynamometer car tests the average draw-bar pull of the various trains over the various runs was determined, proper allowance made for increased train weight due to motor equipment, and finally a reduction of the draw-bar pull thus obtained to horse power, and eventually to kilowatts. Owing to the fact that the maximum speeds on this division seldom exceed 35 miles per hour and that the trains were never less than three cars in length—often reaching eleven cars in length—no correction was made for head end air resistance.

The successive steps were as follows:

(1.)—In order to determine the average draw-bar pull for any given period, the entire area under the dynamometer pen record was found by a planimeter and divided by the length of base of the interval from start to stop, the result being the average height of the dynamometer records between stops. This average height when multiplied by the constant of the instrument, represents the average draw-bar pull between these stops.

(2.)—From passenger records taken during dynamometer tests, the curve, shown herewith, was plotted, showing the ratio of the weight of the live load to the light weight of the train.

(3.)—Dividing the average pull in pounds by the total weight of the train, the average pounds per ton draw-bar pull over the run under consideration, was obtained.

The average pounds per ton draw-bar pull (not tractive effort) for various lengths of run over the Mott Haven Division are shown in Curve 1, of the accompanying curve sheet. Curves 2 and 3 show these values for longer runs, as obtained on the Harlem and Hudson Divisions respectively, and Curve 4, which is the mean of Curves 1, 2 and 3, shows very roughly what may be expecteed to obtain as the average value of the "pounds per ton" draw-bar pull under ordinary steam railroad conditions, on a level and comparatively straight track, with various weights and length of train (three to ten cars, 100 to 400 tons), and at an average speed of about 30 miles per hour.

(4.)—(A graphical method of obtaining the speed in miles per hour between any two stations when the time of run between these two stations is given, was next set forth.)

(5.)—The weight of every train arriving or leaving the Grand Central Station on a given day was obtained, and its average speed between stops determined from the above curves. Knowing, therefore, the average draw-bar pull in pounds required to haul a train, and the average speed at which this draw-bar pull was exerted, the horse power at the draw-bar becomes:

H.P. = foot pounds per minute / 33,000
= draw-bar pull × miles per hour × 5,280 / 33,000 × 60
= draw-bar pull × miles per hour / 375.

(This formula was also presented graphically, from which, knowing the draw-bar pull and speed, the horse power or kilowatts corresponding thereto could be determined.)

Method of Obtaining Daily Load Diagram.

From a careful examination of the weights of all locomotives now in service on this division, it was found that properly powered electric locomotives having a total weight of 65 tons each, all of which would be available for tractive effort, could satisfactorily perform the service of existing steam locomotives. To each train horse power curve, therefore, is added the horse power required to propel a 65-ton locomotive.

This horse power was obtained in the same manner as that required to haul the train and was plotted seperately on the train sheets; evidently, the friction of an electric locomotive in pounds per ton is greater than an equivalent weight of train, but this difference was considered in selecting the proper locomotive efficiency. The sum of the instantaneous values of these individual curves was then plotted. The mean height of this curve was plotted on each sheet, and represents the average horse power required to propel all schedule trains and locomotives during the six hours covered by the sheet.

This average horse power when converted into kilowatts by means of the following formula:

$$\text{k.w.} = \text{h.p} \times 746 / 70\% \times 1{,}000$$

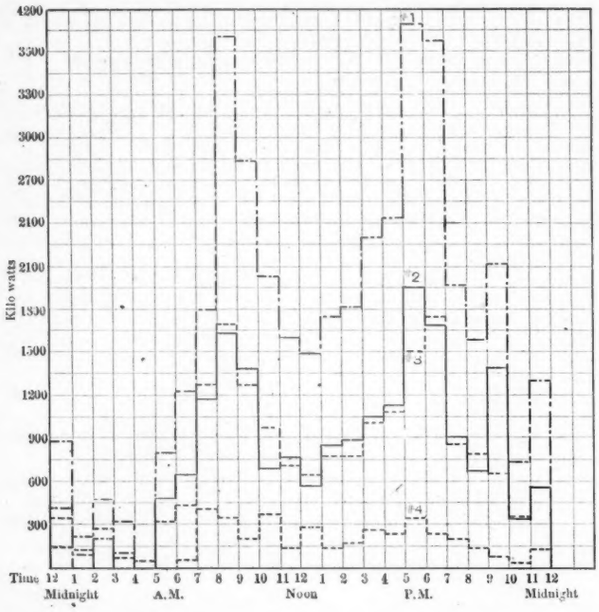
where 1,000 watts = 1 k.w.
746 watts = 1 electrical h.p.
and 70% = efficiency of locomotives

gives the average kilowatt input required at contact shoes of electric locomotives for the period covered by each sheet.

Another curve shown represented the mean average kilowatt input at contact shoes throughout a period of 24 hours, under the same conditions, and the demands of the switching and shop train service were found.

The sum of these curves when plotted as a curve therefore represented the average daily kilowatt input required at the contact shoes of the locomotives for all service.

Curve 1, of the accompanying plate of total load curves, is a condensed load diagram of the entire service, showing the hourly variation of the different classes of service, as deduced from the curves previously determined.



Condensed Load Diagram of the Entire Service, Showing Hourly Variations.

From the curves of average inputs which were determined from the curves, on these sheets, it is seen that the daily average input required would be at the rate of 1,800 kilowatts and, therefore, the total annual input required at the contact shoes of the locomotives, for propulsion alone, would be $(1{,}800 \times 24 \times 365) = 15{,}768{,}000$ k.w. hours. From the total number of tons hauled yearly over this division, including passenger, shop trains and switching service, the ton-miles per year were found to be 250,285,710. Hence, the electrical energy required to haul a ton one mile over this division under the existing conditions would be:

$$\frac{15{,}768{,}000{,}000}{250{,}285{,}710} = 63 \text{ watt hours per ton-mile.}$$

With this figure as a basis and the load factor as determined from the load diagram, the problem of determining the best method of producing, distributing and applying the power was considered.

Choice of System.

While it is the writer's opinion that the alternating current railway motor will yet prove to be the most efficient, all things considered, for long distance railway work, it has not yet, in his opinion, demonstrated its ability to start under load as efficiently or to accelerate a train as rapidly as the direct current motor. The line under immediate consideration was short, the trains numerous and rapid acceleration desirable, all of which are conditions favorable to the direct current motor.

Furthermore, direct current motors with their necessary auxiliaries have become fairly well standardized, and it is the only class of electric railway apparatus available from the manufacturers of the United States without involving experimental work and large development expense.

In view of these facts and the probable necessity for rapid construction, the writer refrained from advising anything of an experimental nature and, therefore, recommended the direct current system in combination with the third rail for the main line, and overhead construction for the yards, all of which have demonstrated fully their ability to meet the conditions imposed by railway operation so far as motive power is concerned, although there has not yet been an electric installation on any existing terminal that is as complex, or into which anywhere near the number of heavy trains enter as on this section of road.

Had the length of road under consideration been considerably greater, and had it been thought possible to secure sufficient time to conduct experiments or invite demonstrations by manufacturers of alternating current motor equipment, this class of apparatus would have been more seriously considered.

Discussions and Analysis of Plans and Estimates.

In the preparation of estimates, twelve distinct plans of generation and distribution were considered and the results tabulated as shown in the accompanying table. All the estimates were computed upon the same basis so far as cost of fuel, labor and losses in transmission were concerned. The different headings in the table here shown are deduced from another table not here published, the columns of which were as follows:

Column A.—Total Cost of Entire Installation.—Erected complete, consisting of power house, transmission circuits, feeders, substations, track construction chargeable to electrical equipment, overhead construction and electrical locomotives.

Column B.—Total Operating Expenses per Annum.—Including wages in power house and sub-stations and on rolling stock, together with all coal, oil, water, waste, repairs, etc.

Column C.—Fixed Charges per Annum.—Including interest at 4 per cent. on total investment, and taxes at 2 per cent. on buildings, sites, machinery and electrical locomotives.

Column D.—Total Expense per Annum.—Made up of Column B plus Column C.

Column E.—Operating Expenses per Annum at Power House.—Including coal, water, oil, waste, etc., and repairs and wages.

Column F.—Operating Expenses per Annum at Contact Shoe.—Including coal, water, oil, waste, etc., and repairs and wages in power house; oil, waste, repairs and wages in sub-stations; and repairs (labor and material) on transmission lines.

Column G.—Total Expense per Annum Exclusive of Rolling Stock.—Including operating expenses per annum at contact shoe (as in preceding Column F) plus fixed charges as follows: interest at 4 per cent. on total investment (less cost of electric locomotives) and taxes at 2 per cent. on buildings, sites and machinery.

Column I.—Total Locomotive Miles per Annum.—Determined from information furnished through the Operating Department.

The explanation of the columns in the table is as follows:

Column H represents the operating expenses per k.w. hour at power house switchboard. Column M represents the operating expenses per k.w. hour at contact shoe. Column N represents the total cost per k.w. hour delivered to motor terminals, exclusive of fixed and operating charges on electric locomotives. The cost per k.w. hour at motor terminals differs from the cost per k.w. hour at the contact shoe only when batteries are carried on the locomotives, in which event the cost per k.w. hour at the motor terminals is increased over the cost per k.w. hour at the contact shoe by the cost of energy lost in the batteries. Column J represents the operating expenses per electric locomotive mile. The values in this column are directly comparable with values now obtained in the present steam locomotive service, except that the operating expenses for steam locomotives as shown by the performance sheets of the Motive Power Department do not include any charge for water. From the best information available, the cost for water for the present service on this division is about .987 cents per locomotive mile, which amount added to the present cost as shown on the locomotive performance sheets, gives an amount which should be compared with the values in Column J. Column K represents the fixed charges per electric locomotive mile, and is here tabulated merely as a step in obtaining. Column L (which is Column J plus Column K) represents the total cost per electric locomotive mile.

Plans 4 and 5 bring out quite clearly the difference in the cost of operation between two sub-stations and one, both plans permitting the location of the power station on the river front.

The difference in favor of Plan 5 is entirely due to the saving in labor of one sub-station.

Plans 6, 7 and 8 were studied with the object of ascertaining whether the purchase, instead of the generation of power, would offer a satisfactory solution of the problem.

The purchase of both D. C. and A. C. energy was considered on the lowest basis that it was thought possible for any existing company to furnish it, and it was found that the D. C. energy would cost the railroad company one-half cent more per k.w. hour than the A. C. energy, in consequence of the interest, depreciation, maintenance, etc., of the transmission lines, rotary converters and other sub-station apparatus which would have to be furnished by the energy producing company.

Owing to the more or less complex system of overhead or third-rail yard construction made necessary by the nature of the case, and the advantages to be obtained by their elimination in the substitution of locomotives which could, for switching service, be self-contained, though normally supplied with energy from the working conductors, a study was made of electric locomotives carrying batteries.

The results of these studies made under several different assumptions are shown under Plans 9, 10 and 11. From Columns L and N it is evident that whatever may be gained by the elimination of the overhead construction is largely offset by the additional cost of operation, although it will be observed that the cost per locomotive mile of Plan 9 compares favorably with the cost of Plan 12.

Plan 12 differed only from Plan 5 in a slight reduction in the capacity of the converting apparatus in the power house and substations and the substitution therefor of two storage batteries (one located in or near the power house and one in the sub-station), each of such capacity that it, together with only a portion of the main station and sub-station machinery, would be capable of taking over the entire load of the line for a short period of time in cases of emergency.

The additional first cost and the slight increase in annual expense (as compared with Plan 5) represented by a reserve station capacity of this nature, was thought to be of secondary importance only, in view of the increased reliability of operation thereby obtained. The increased cost of operation in this plan over that of Plan 5 is due to the fact that the battery maintenance was figured at 10 per cent. per annum, which is considerable higher than is

TABLE 1.

CHARACTER OF STATIONS, ETC.

Plan.		Column E $H = \frac{\text{Total k.w. hours at power-house switchboard.}}{}$	Column F $M = \frac{\text{Total k.w. hours at contact shoe, annually.}}{}$	Column G $N = \frac{\text{Total k.w. hours at motor terminals, annually.}}{}$	Column B $J = \frac{}{\text{Column I}}$	Column C $K = \frac{}{\text{Column I}}$	$L = (\text{Column } J + \text{Column } K)$
1.	Direct current power station at center of line and contiguous to tracks. 600 volt working conductor, no batteries	.447c	.60c	1.06c	14.02c	6.58c	20.60c
2.	Same as No. 1, with batteries in power house	.472	.66	1.137	14.65	6.71	21.36
3.	Same as No. 1, with battery sub-station near Grand Central Station and Mott Haven Junction	.475	.668	1.20	14.7	7.25	21.95
4.	Alternating current power station on river front near center of line, with rotary converter sub-stations near each end of line. 11,000 volt A. C. and 600 volt D. C.	.572	.715	1.287	15.2	7.58	22.78
5.	Combined D. C. and A. C. power station at Harlem River near one end of line and one rotary converter sub-station near the other end of line. 11,000 volt A. C., 600 volt D. C., no batteries	.570	.666	1.19	14.7	7.18	21.88
6.	Direct current feeders from Manhattan Railway sub-station located near center of line. Transmission from sub-station to working conductor. 600 volts D. C. energy to be purchased	2.5	2.650	2.748	34.64	2.89	37.53
7.	Rotary converter sub-station at center of line. A. C. energy to be purchased from Manhattan Sub-station and transmitted at 11,000 volts. Energy to cost ½ cent less per k.w. hour than D. C. energy delivered	2.5	2.336	2.508	31.50	4.23	35.73
8.	Two rotary converter sub-stations, one near each end of line. A. C. current to be purchased from Manhattan sub-station near center of line	2.1	2.336	2.504	31.50	3.93	35.43
9.	Combined A. C. and D. C. power station near Harlem River at end of line. One sub-station near other end, and batteries carried on locomotives charged from working conductor	.519	.629	1.122	16.58	7.76	24.34
10.	One rotary converter sub-station near center of line, A. C. current purchased from Manhattan sub-station No. 7, batteries on locomotives charged from working conductor	2.12	2.4	2.502	34.40	4.08	38.48
11.	Direct current feeders from Manhattan sub-station No. 7, near center of line. Batteries on locomotives charged from working conductors	2.5	2.738	2.742	37.81	2.51	40.32
12.	Combined A. C. and D. C. power station at Harlem River near outer end of line. One sub-station near other end. Batteries in power station and sub-station. A. C. transmission 11,000 volts, D. C. conductors 600 volts	.55	.775	1.335	15.80	7.83	23.63

Table of Estimates on Plans for Proposed Electrical Equipment of the N. Y. C. & H. R. R. R. Between Grand Central Station and Mott Haven Junction.

ordinarily assumed, and will probably be considered excessive by some.

A battery of this kind would not only serve as a reserve, but would prove of considerable value as a regulator of potential along the line, and in addition it would, notwithstanding its inherent losses, tend to reduce the power house operating costs by taking up the excessive load fluctuations of the system and permitting the load upon the engines to be maintained at or near their most efficient working capacity.

It was considered of the utmost importance in an installation of this magnitude that the number of interruptions of power supply be reduced to a minimum, that no device which could increase the safety and reliability of the plant should be omitted, and that the probability of future extensions of the electrical system should be considered. As best fulfilling the above conditions, therefore, Plan 12 was the one specifically recommended for adoption.

Operating Expenses.

A careful compilation of all the expenses entering into the operation of the present steam service was made, and the following comparative table (Table 2) of relative costs is believed to be correct, assuming that the present locomotives running between Mott Haven Junction and Grand Central Station should be abandoned and the service now performed by them duplicated by electric locomotives operated in accordance with Plan 12. It is assumed that the electric locomotives will be operated by the same class of men as those who now operate the steam locomotives, and that they would receive the same rate of pay that they now receive.

This condition is not favorable to electric traction, as it is not ordinarily necessary to have two men to operate an electric motor, but in the writer's judgment it is not advisable to operate a service of this class under such exacting conditions without two men on each locomotive.

If the motor car system should be adopted, as it probably would be were the electrical equipment extended beyond Mott Haven Junction, or if the forward guard or brakeman were allowed to take the place of the second man while passing through the tunnel and yards, a saving equivalent to his wages could thereby be effected.

With two men of the same skill as at present employed on the locomotives, the figures are as follows:

TABLE 2.

	Steam	Electricity
Operating expenses per locomotive mile exclusive of fixed charges, but including water, labor, cost of cleaning and repairing tunnel, and all other expenses of locomotive operation	23.05	15.80
Fixed charges per locomotive mile assuming that it now requires 40 locomotives to perform the present service and that 33 electric locomotives could perform the same service	1.13	7.83
Total in cents	24.18	23.63

From these figures it appears that while there would be a slight annual saving in operating expenses in favor of electricity, it is not sufficient to warrant its adoption on the grounds of economy alone, although its adoption can be justified on other grounds.

In connection with the investigation, a series of comparative acceleration tests of steam locomotives and electrical equipment were made at Schenectady, the results of which are set forth in another paper prepared by Mr. W. B. Potter and the writer. (This will appear in a later issue.—Editor.)

"A Treatise on Roofing" is the title of a 24-page pamphlet issued by the American Insulating Material Manufacturing Company, of St. Louis, Mo. It contains a discussion of roofing, its requirements, manufacture and application, which should be read by all who are concerned in the application or maintenance of roofs on buildings or cars. This company presents facts from its extensive experience. The pamphlet includes descriptions of Sawyer's plastic and flexible car roofing which will especially interest our readers. The address of the company in St. Louis is 213 North Third street.

The American Blower Co., Detroit, Mich., have recently issued a catalogue descriptive of their disc ventilating fans and also a dry kiln catalogue. In the fan catalogue their steel plate disc fans are illustrated in all types, belt-driven and direct-connected steam engine and electric motor driven, adaptable for all kinds of drying, ventilating and other blowing service. The dry kiln catalogue illustrates their "moist-air" and blower dry kilns, together with the special apparatus and fittings necessary. Special lumber trucks are shown for use in the kilns, and also a simple return steam trap of their manufacture is shown for returning condensation from heater coils to the boiler.

The Baldwin Locomotive Works pamphlet, "Record of Recent Construction," No. 35, is devoted to rear truck locomotives. The origin of the use of trailing trucks is explained by text and engravings illustrating the wide firebox locomotives which required them. Examples of the "single" of the Philadelphia & Reading, the Atlantic types of the Chicago, Milwaukee & St. Paul, the Prairie types of the Burlington, and the Mikado type of the Bismarck, Washburn & Great Falls are illustrated by half-tones, with tables of dimensions. The pamphlet closes with an illustrated description of the Rushton trailing truck, which has been applied to a number of recent Baldwin engines.

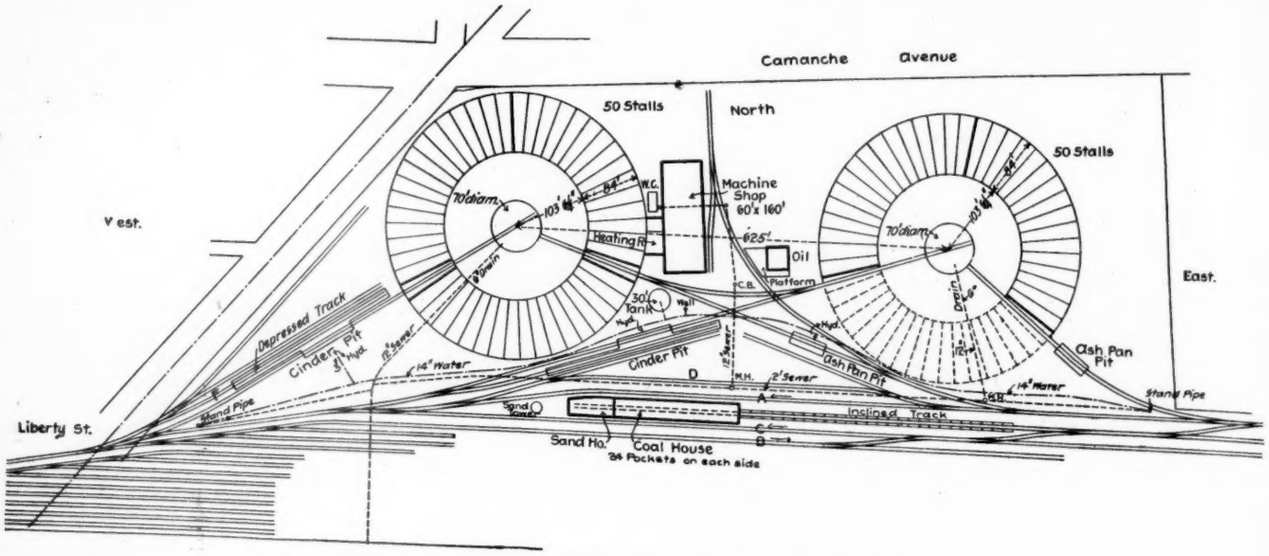
MASTER MECHANICS' ASSOCIATION REPORTS.

(Concluded from July.)

UP-TO-DATE ROUNDHOUSES.

Committee—Robert Quayle, D. Van Alstine, V. B. Lang, G. M. Basford.

[Editor's Note.—This report is divided into four papers presented by the committee from its individual members. Mr. Quayle discussed the plans of terminals recently constructed, Mr. Van Alstine presented an ideal plan for a locomotive terminal, Mr. Basford presented a large number of details of recently constructed roundhouses and facilities connected with them, and Mr. Lang discussed the operation of roundhouses. Selections from the first three are presented here. From Mr. Basford's paper the portion on ventilation is reproduced.]



The Clinton, Iowa, Roundhouses.—Chicago & Northwestern.

Plans of Terminals.

I submit for your consideration, first, a plan of roundhouse terminals at Clinton, Iowa, on the Chicago & Northwestern Railway. This plan I submit for the reason that it is flexible, and one, two, three, four or more roundhouses may be set in line. This part of the road points east and west, and it is the opinion of the writer that the roundhouses ought to be set parallel with the tracks.

At Clinton, Iowa, two divisions terminate. The Galena division, which runs from Chicago westward to Clinton, 138 miles, and the Iowa division, which runs eastward from Boone to Clinton, 202 miles. These are the lengths of both passenger and freight divisions.

At a busy terminal, where there are from 200 to 350 locomotives to be handled a day, it is very necessary that engines should have track facilities that will enable them to be moved easily from the roundhouse up into the freight yard to be coupled on to the trains without any interruption by an opposing movement of locomotives. It is also necessary to have an additional track that will enable the locomotive to come from the freight yard up and into the engine house without being detained by opposing engines. This not only holds true for freight locomotives, but also for passenger locomotives.

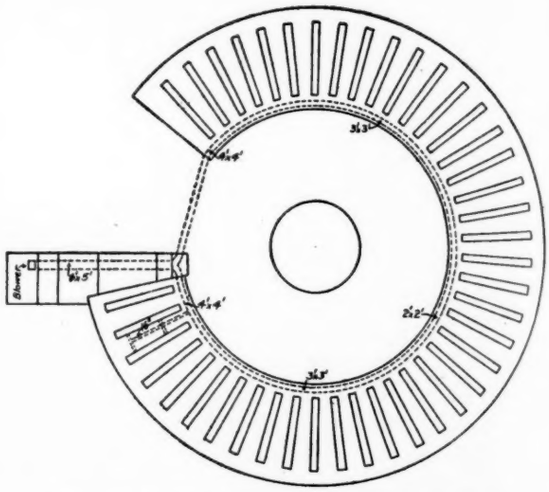
I will first call your attention to the movement of passenger locomotives from the passenger depot, and I do this because on some roads they use a better quality of coal for their important passenger engines than they do on their freight engines; consequently, they have the coal better taken care of, broken up and placed on the tender in better condition, and for this reason it is necessary to have one side of the coal house given over to passenger coal, and hence it is necessary to have a track on the side of the coal house over which the passenger coal is to be delivered to locomotives set aside for passenger locomotives, and on this plan the northbound track, marked "A," is known as the track for the movement of passenger locomotives. The depot being to the east of the roundhouse, the engines cut off from their trains and come up through the yard westbound until they enter upon track "A," on which they pass up to the coal chute and take coal, and immediately at the west end of the coal chutes is the sand tower from which they take sand. They then pass on down to the standpipe and take water, and then move to the switch, which gives them a clear way over their cinder pits and into their respective roundhouses, whether they be Galena or Iowa division engines.

Your attention is next called to the passenger locomotives leaving the house and going up to the depot to be ready to couple on to train after its arrival. If the passenger engine is in the west roundhouse, which belongs to the Iowa division, it will pass out of the roundhouse on the track to the east of the roundhouse, and will pass over what is termed the ash-pan pit, and if the ash-pan needs cleaning it will be cleaned out, and the engine will pass onward down toward the depot, connecting with track "A," where they have access to a standpipe, and can fill their tanks with water at that point, if necessary.

When passenger engines go out from the east roundhouse they go down to the eastbound track and take water at the same penstock, and on eastward to the depot.

Now, we will follow the freight engines from the point of giving up their freight trains to their arrival in engine house. First, be it understood, that the freight yard in this plan is to the west of the roundhouse, and all east and westbound trains terminate in the same freight yard, and as it is located west of the roundhouse, they all have to come eastward past the coal chute on track "B," and then cross over to coaling track, "C," where they will take coal and pass westward to the switch, and go into either east or west engine house in the same manner as described above for passenger engines.

The freight engines will come out of each of the east and west houses in the same manner as shown above for passenger locomotives, except that instead of going up to the passenger depot they will only go to the first switch and then head up on track "A," and if there are no passenger engines to detain them on the coal-house track, "A," they will pass on said track up into the freight yard. But, should there be passenger engines taking coal at the coal house on track "A," they will take track "D," which we will call the run-around track.



Plan of Roundhouse with Reference to Vent.

This plan could be extended indefinitely, so far as relates to number of roundhouses. Would also call attention to the fact that

this plan calls for a depressed track, of which the writer is in favor, as his experience during some severe winter weather has caused him to discount very materially the use of pneumatic hoists for such purposes. Would recommend that we should always have pits long enough to at least clinker two engines at a time.

The Ideal Roundhouse.

The ideal roundhouse is one which handles engines with the least possible delay at the lowest possible cost. It provides inbound tracks of sufficient length to store a large number of engines, on which are located coal chutes, sandhouse and cinder pits.

The coal chutes consist of 40 or 50-ton pockets on scales, into which hopper-bottom cars may be unloaded. The track above the pockets is reached by a 4 per cent. or 5 per cent. grade. At one end of the coal chute are the sand pockets, which are filled from cars, same as the coal pockets. After the sand is dried it is stored in elevated pockets, from which it is drawn into sand boxes. The cinder pits are 150 ft. long, and depressed track about 8 ft. below bottom of cinder pits, to allow of cheap loading of cinders into cinder cars. There should also be short cinder pits in out-bound tracks for cleaning ash pans of out-bound engines, and cleaning fires of switch engines.

Standpipes should furnish water to engines on in-bound and out-bound tracks. The turntable is 70 ft. long and operated by power. The roundhouse is 80 ft. long in the clear, with doors 12 ft. wide and 16 ft. high.

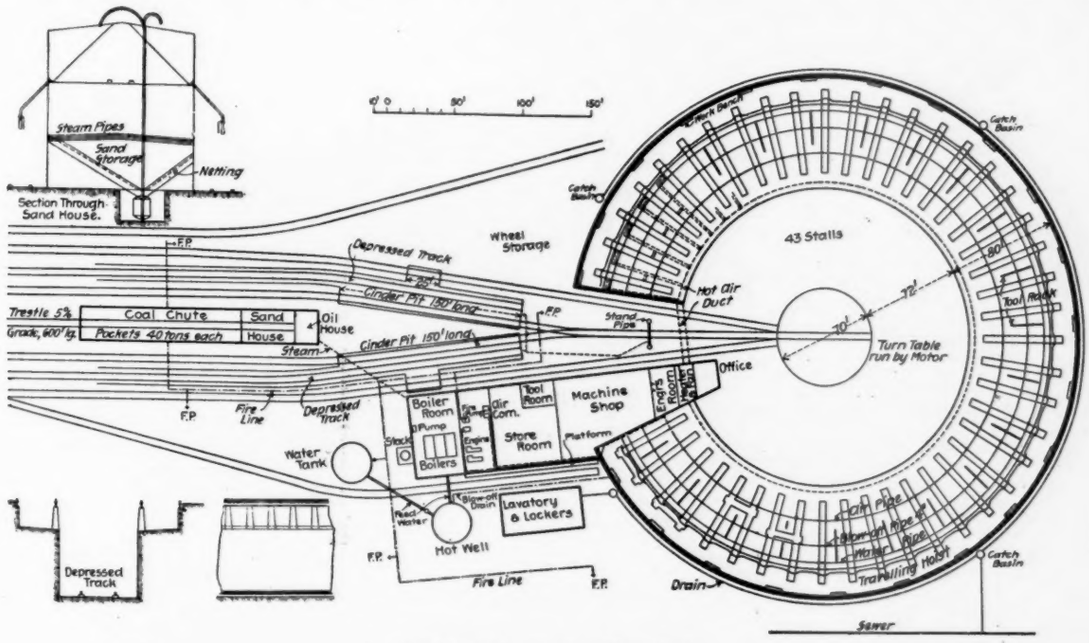
It is heated by hot air from heater and fan, which passes around the house through an underground duct on the inside circle, and is

Heating and Ventilating.

Nearly all roundhouses of recent construction are equipped with fan systems, these being considered as furnishing the ideal method of heating. For small houses, steam pipes in the pits seem to be the most economical. In the plans accompanying this report are a number of different arrangements of conduits from the fans, most of them underground. The conduits may then be of brick and concrete, and are permanent. When underground, they are also entirely out of the way and do not obstruct the light. Various methods are employed to distribute the hot air to the pits, the chief point of interest being the methods of delivering the air under the engines and tenders for the purpose of quickly melting snow and ice. These require no comment, but it is evident that the plans are not of equal merit in this respect. The roundhouse pits of the Jersey Central at Elizabethport are fitted with elbows to direct the air to the machinery. These, when pushed into the bushings in the walls, automatically open the delivery dampers.

For good ventilation, the volume of air required from the fan is much greater than is required to pass through the fan for heating alone. A good rule is to require the air to be renewed every eight or ten minutes. Practice in heating and ventilating is not by any means uniform, and an attempt has been made to secure information which shall be a guide to good practice.

The variable factors are: Volume of house per stall, outside temperature range, character of exposure, use of live or exhaust steam, location of fanhouse, space available for fan and amount of heated air to be returned to the fan. In a roundhouse the air



An Ideal Locomotive Terminal.

distributed to pits through underground pipes. The air to be heated is not taken from inside the roundhouse. A hot well, into which is drained all the exhaust steam from the plant, as well as steam from engines blown off, furnishes hot water for washing out and filling up, and for stationary boilers. The power-house boilers are arranged to burn front end sparks where the price of coal makes it profitable.

The engine room is provided with engine, dynamos, washout pumps, fire pump and air compressors. The machine shop is provided with lathes, bolt cutter, drill press, shaper, grindstone, planer, screw press, blacksmith forge and anvil. The store room contains all necessary supplies, except oil, and a tool room for small tools. The engineer's room is located close to the roundhouse foreman's office, and contains bulletin boards and desk. The roundhouse foreman's office is centrally located. The lavatory is provided with wash basins, shower baths, closets and lockers for engineers, firemen and roundhouse men. The oil house should be conveniently located for taking oil cans to and from engines.

In the roundhouse are tool racks between pits for pinch bars, wrenches and heavy tools, work benches on outer wall supported by brackets, drop pits for engine truck and driving wheels, an overhead track for lifting smokestacks, smokebox fronts, steam pipes, steam chests, pistons, cylinder heads, crossheads, etc., electric lights, electric and air motors for cylinder boring, etc. The overhead track has trolleys and chain hoists. The drop pits have hydraulic jacks on carriages for raising, lowering and moving wheels. The rodman is provided with a work bench on wheels. A wheel storage yard is conveniently located for getting wheels into and out of the roundhouse. If fuel oil is used for fire kindling a 6,000-gallon storage tank, underground, is located so that it can be filled from a tank car, and oil easily pumped from it for use in the roundhouse.

should not be returned to the fan. The form of roof affects the heating. An average of about 33,000 cubic feet of space per stall seems to represent usual construction. About 2,000 cubic feet of air delivered per minute per stall gives good results. The committee found one case in which 800 cubic feet per minute seemed to be ample. A range of from 125 to 150 deg. F. seems to be satisfactory for the delivery temperature. To estimate approximately the amount of steam in pounds per minute required for the heater, multiply the total volume of air supplied per minute by the number of degrees to which it is heated, divided by the constant 55.

In order to secure definite figures, one of the leading firms of engineers, making a specialty of heating and ventilation, was asked to submit suggestions based upon the roundhouse shown in Mr. Van Alstine's portion of this report, the conditions being those of the climate of Chicago, the minimum outside temperature being 20 deg. below zero, the inside temperature to be 70 deg. and the range of temperature of the hot air to be from 125 to 150 deg. This information is as follows:

Number of stalls	42
Approximate cubical contents per stall	34,700 cubic feet
Air supply per stall per minute	2,000 cubic feet
Total air supply	84,000 cubic feet
Temperature air supply	140° F.
Size of fan	11 ft.
Speed of fan	150 r.p.m.
Size of engine	11 x 14
Lineal feet in heater	8,500 to 9,500

"These figures are subject to some change, depending, first, upon the character of the exposure, the probable minimum outside temperature, variable steam pressure, and the amount of hot air returned to the fan. You can readily see that unless we were given

a specific case and knew all of the conditions pertaining thereto, it is quite impossible to figure closely.

"We enclose herewith a sketch in which is shown in dotted line a suggested system of underground conduit for this roundhouse. We have shown also the approximate size of this conduit. If the fact that it is arranged to run under the radial tracks is a disadvantage, it could, of course, be placed near the outer wall. The proportions of this sketch are probably wrong, because the blueprint enclosed is not scaled. The dimensions thereon are evidently not intended to be perfectly accurate.

"Assuming the cubical contents per stall about 34,000 cubic feet, and, assuming the temperature of delivery 125 deg., a careful computation, taking into account only the heat loss from walls, roof and windows, and making no allowance for the opening of doors and other accidental ventilation, we find that it will be necessary to supply 1,200 cubic feet of air per minute per stall to maintain an inside temperature of 70 deg., with an outside temperature minus 20 deg. In order, therefore, to safely provide for accidental ventilation, the air supply should not be less than 2,000 cubic feet. This will serve to show that an air supply of 800 cubic feet would hardly be large enough unless there were unusually favorable conditions to be met."

To secure the best conditions of ventilation and heating, it seems wise to consult the leading firms dealing in this apparatus and provide a liberal appropriation for the equipment, and to secure a fan capacity far greater than sufficient to maintain a comfortable temperature at all times, then to drive this fan hard enough to secure good ventilation through the smokejacks and roof ventilators.

MODERN WATER SUPPLY STATIONS FOR LOCOMOTIVES.

From a paper by F. M. Whyte, before the Master Mechanics Association.

Editor's Note.—This paper is a record of current practice, and cannot fairly be presented in abstract. Selections are reproduced and the reader referred to the original, which is the most complete discussion of this subject available. The chapters on track tanks and water scoops are specially valuable. The illustrations are numerous, and comparatively few of them have been published before.

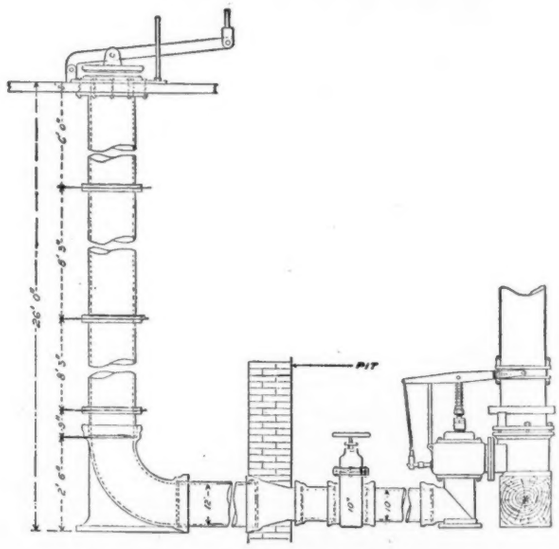
Quite generally the pumping plant for a locomotive water station is so small that only the simplest arrangements are provided; the number of boilers is seldom greater than one or two, and because one man can attend this number and the services of one man are needed, labor-saving devices are not needed in the average steam plant. The boiler house is built as substantial as circumstances allow; it is located so that fuel can be taken to it conveniently and refuse taken from it. When the conditions allow, the boiler and pump are placed in the same building.

The exhaust from the steam pump should be connected to the suction pipe at some distance from the pump, the steam being directed toward the pump where the steam enters the suction. This arrangement will assist the suction, reduce the back pressure on the steam end of the pump, and raise the temperature of the water, all of which are desirable results. Those who have used the arrangement give caution that care must be exercised to keep the exhaust pipes free from leaks.

The internal-combustion engine, in the form of gas or gasoline engine, is being used more and more for providing power for pumping, and there are conditions which can be fulfilled very nicely with this kind of power. Where the work is intermittent, or can be made so, and the attendant is employed to advantage elsewhere when not attending the pumps, these engines have been used with much satisfaction. The gas engine or gasoline engine pumphouse should be thoroughly ventilated at all times. It is the general practice to use gasoline in these engines, but quite recently it has been found that hydro-carbon, a by-product of the Pintsch gas plants, can be used in these engines, and when this hydro-carbon is available there may be a material reduction in the cost of operating the engine. If a road is supplying its own engines from its own gas plants a very convenient way for handling the liquid is to provide metal casks of a capacity of about 50 gallons; or a sufficient number of tank cars may be provided, the cars to be sent out over the line and stopped wherever a supply of oil is needed, the oil tank at the pump house filled, and the tank car moved on to the next station. These engines may be handled in such a way as to be extremely economical from the standpoint of labor costs; they can be so arranged that the only labor shall be that of starting the engine, it being cut off automatically when the water tank is filled. The labor cost, then, is such as is necessary to provide sufficient attention to start the engine before the tank is emptied.

Compressed air gives a very convenient means of raising water from deep-driven wells, because the operating machinery is all above ground and the pipes, if they are found out of order, are easily and quickly replaced. Another condition which justifies the use of compressed air is the necessity of using a number of wells to provide the necessary quantity of water, allowing the water from the various wells to flow either to the place where needed, or to flow to the suction of force pumps. The air-lift will not deliver the water horizontally to any great distance, so that when the lift, or well, is at a greater distance than 40 ft. from the place where the water is to be used it is necessary to raise the water perpendicularly at the well to such a height that it will be delivered by gravitation to the place desired, or to provide other means for the horizontal delivery. This means of pumping can be used to advantage also when it is desired to locate the pumping machinery at some distance from the well. This condition may arise when it is difficult to get the machinery or the fuel for operating it, sufficiently close to the well; or when it is possible, by locating the machinery at some some distance from the well, to keep the attendant busy at other work, when his services are not required all the time for pumping water. Also compressed air may be available for other service at the place where required, and in the use of it for raising water a considerable economy may be shown.

Information concerning the proper proportioning of air lifts has been the result of experience obtained by those who are engaged in making air compressors and in designing air lifts, and the formulæ which have been deduced from experience are treasured highly and are not available for publication. The general practice is, however, to make the relation of the submersion to the lift from 4 to 3, to 3 to 2. This is the "working" submergence as distinguished from the height at which the water stands in the well before pumping is begun; generally the water level in the well falls as soon as pumping is begun. If a lower percentage of submergence is used the cost of operation is increased. The weight of the column of water above the air inlet is readily calculated, and this will equal the pressure at which the air must be delivered to the point where the air and water are mixed. The starting pressure will be greater than the working pressure. The working pressure, divided by the atmospheric pressure at the altitude of the well, will give a quotient which, if unity is added, will give the number of volumes of free air required. The capacity of the well may be calculated by allowing 15 gallons per sq. in. of cross section of pipe per minute, or by taking the rate of flow in the discharge pipe at 5 ft. per second. For heights of from 15 to 50 ft. there will be required 2 or 3 cu. ft. of air at atmospheric pressure per cu. ft. of water delivered; for heights of from 50 to 100 ft. it is considered best to provide three to four cu. ft. of free air at atmospheric pressure for each cu. ft. of water delivered. The efficiency of this system of pumping is about 50 per cent. maximum, and may be as low as 15 to 20 per cent.



Ideal Piping Arrangement for Water Cranes.

Suggested by Mr. WHYTE.

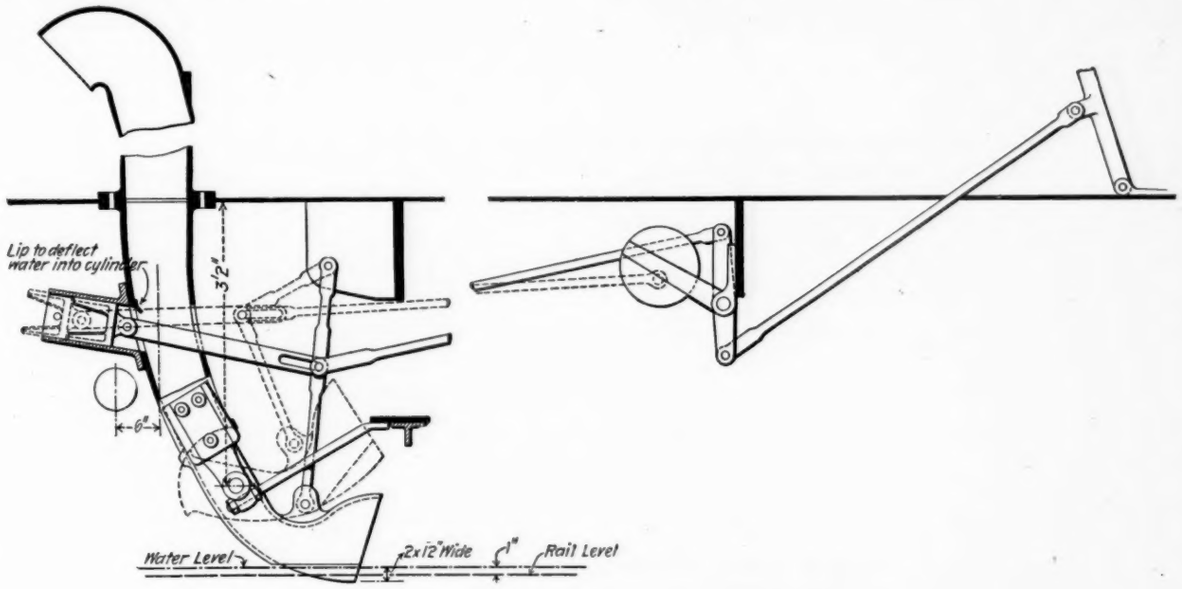
Water Cranes.—Cranes are necessary where the reservoir tank cannot be located conveniently for delivery direct to the locomotive tank. The water for the crane is generally supplied from a reservoir tank. The present rush of both passenger and freight business makes necessary the saving of every minute possible, and more attention is being given to means for delivering quickly the water to the locomotive tank; with the object of delivering the water as promptly as possible, the pipe from the reservoir tank to standpipe is made larger in diameter than was commonly the practice; the crane, or standpipe, is made larger; and the valve is made with a more direct passage for the water. In fact, a serious study is being made of the friction of water in pipes, valves and bends, and as a result some previous designs are being revised or discarded. It will be appropriate to give here the results of some tests made by Mr. T. W. Snow. A 90-degree bend of a radius equal to one and one-half times the diameter of the pipe, for pipes 8 to 14 ins. in diameter, offers a resistance to the flow of water equal to that of 100 ft. of straight pipe; a 12-in. pipe, 300 ft. long and having three bends of 90 degrees each, the head being 24 ft., gave a flow of 4,000 gallons a minute; under the same conditions, except that the length of the pipe was 900 ft., the flow was 3,200 gallons a minute. With an improved standpipe, the flow under conditions similar to the first instance given above was increased to 5,000 gallons a minute. These data will impress the necessity of having direct passages. Of course, there are various designs of cranes and each is given peculiarities which are held out as inducements to pros-

pective buyers, but it is impossible to refer to them here; there are some things, however, which are considered essential features, and some of these may be mentioned. The pipe connecting the reservoir and tank and the crane should be larger than the crane; one size larger seems to be in accordance with improved practice, and the change in diameter is made just outside of the crane pit, or as close to the valve as possible. Some device should be provided to protect the pipe and the valve against shock due to sudden closing of the valve. The valve passages should be made as direct as possible, so that the resistance to the flow of water may be the minimum; this should be considered in connection with the 90-degree bend, which must be made in changing direction from the horizontal delivery pipe to the vertical standpipe. It should be possible for a person to operate the crane while standing on the ground, and also while standing on top of a tender. The standpipe, for cold climates, should be drained automatically when the controlling valve is closed. The arm should have considerable motion in a vertical plane, so that there will be some adjustment possible to accommodate for locomotive tenders of different heights, and to clear the better the coal board and the ends of cars. It should be positively locked in the position parallel to the track, so that it cannot be blown by the wind, or placed accidentally into the position to foul trains. Drainage must be provided for the crane pit. For proper security a gate valve should be placed inside of the crane valve, and there should be another valve near the reservoir tank.

Track Tanks.—Track tanks are made 6 ins. or 7 ins. deep and 18 ins. to 20 ins. wide; they are placed central between the rails of a track, and the top of the tank, or, more particularly, the level of the water in the trough, must bear a fixed relation to the top of the rail. The tanks are of various lengths; some are 1,200 ft. long, others 1,400 ft. long, and others are 1,600 ft. long, and the Lake Shore & Michigan Southern is making them 2,500 ft. long where there is room. The length is determined by the maximum amount of water which is to be delivered into one locomotive tank, or the track tanks are made of sufficient length that the tanks of two locomotives coupled together can be filled with water; this is to provide for "double-heading"; the scoop of the leading locomotive is dropped at the approach to the track tank, and the scoop of the other locomotive is dropped when the middle of the track tank is reached. It is necessary to make the tanks level, but it is not necessary to locate them on tangents; the Philadelphia & Reading has a tank on a curve of 2 degrees; some of the railways in England do not hesitate to locate track tanks on curves.

A slope is provided at each end of the track tank so that if it happens that the scoop is not raised before the end of the tank is reached the scoop will ride up on the incline and be raised over the end of the trough. The scoop is arranged, usually, so that when raised as high as the top of the track tank it will be raised higher than the top of the rail, even though the operator fails to do his part. Also, an incline is provided sometimes for the approach to the tank at each end, so that if the scoop is dropped too soon it will ride the incline into the trough. The slope usually provided is too abrupt; in England an easier slope is provided. Of course, it happens sometimes, when the raising of the scoop is dependent upon human energy, the raising is neglected or some of the machinery is out of order, and the end of the track tank is torn out; this difficulty is not particularly serious, but it is annoying; to facilitate repairs the lower end of the scoop is made in such a way as to be easily renewable, and the end of the track tank may be made of a piece of plank bolted to the tank. If the slope is 20 ft. or 25 ft. long the tank will be injured less frequently.

Track tanks are not storage tanks; they must be refilled after each passage of a scoop through them. Track tanks are supplied from reservoir tanks usually, and the size of pipe through which water is delivered to the track tank will be determined by the minimum length of time allowed to fill the track tank, and by the location of the inlets to the track tank. The gravity head to produce flow in the tank is not great; therefore, in order to increase the rate of flow, the distance through which the water must flow in the tank should be as short as the demands require and circumstances will allow. The rate of flow in the tank cannot be assisted by pressure, but it can be assisted by velocity if the stream is directed into the tank properly. For instance, if the inlet is in the end of the tank and the water is directed lengthwise of the tank, then the water may be forced into the tank at considerable velocity, and so reduce the time of flow to the opposite end of the tank; on the other hand, if the water is admitted vertically through the bottom of the tank, the water must be run in slowly enough to prevent overflowing the sides. The bottom inlet may be used and the water be admitted at a considerable velocity by placing a deflector at the inlet, so that a part of the water will be directed toward one end of the tank and the remainder be directed toward the other end. The bottom inlet is the usual one, and this is covered with a grating to keep out heavy, solid substance. Disregarding any possible velocity head, the location of the inlet, or inlets, for most rapid filling will be understood readily from the following explanation: If the tank is 1,600 ft. long and 7 ins. deep, and the one inlet located at one end, the gravity head is, of course, 7 ins. in 1,600 ft., and frequently this is overcome by a strong wind blowing in a direction opposite to the flow; if the inlet is placed at the middle of the length, the gravity head is 7 ins. in 800 ft.; with two inlets each should be placed at a distance from each end of the tank equal to one-quarter the length of the tank. If there is to be only one inlet for each tank, and this one located at the end of the tank, the approach end should be preferred. If the water is to be kept from freezing by circulating it through the tanks and through injectors or other heater, the relative locations of inlets and outlets will be such that there will be no "short circuiting" of the heated water, and therefore no "dead ends" in the tanks. The general practice in America is to control the flow of water into the tanks by means of a valve operated by the attendant at the pump house. Immediately after a scoop has been run through the tank the attendant opens the valve through which is controlled the flow of water into that tank, and he closes the valve again when the tank is filled. Sometimes an annunciator is placed in the pump house to give warning when the tank is filled, and sometimes the attendant must go to the tank and see when it is full. At other times the attendant opens the valve a certain amount and leaves it open for a certain length of time, and then closes the valve. All of these uncertain conditions make possible, between engine crews and pump attendants,



Balanced Water Scoop.—Great Northern Railway, England.

Designed by H. A. IVATT, *Locomotive Superintendent.*

The Lip Diverts Water into the Cylinder, the Pressure of which Aids in Lifting the Scoop in Fast Running.

disputes concerning the amount of water in tanks at various times. A more positive, automatic arrangement is used in England, the controlling valve being operated by means of a large float, the float being in a tank of water which is connected to the track tank by an equalizing pipe.

STANDARD SPECIFICATIONS FOR LOCOMOTIVE DRIVING AND TRUCK AXLES.

Committee—A. E. Mitchell, S. Higgins, W. S. Morris, L. R. Pomeroy.

Your committee selected to report on the subject of "Standard Specifications for Locomotive Driving and Truck Axles," when notified of their appointment, promptly organized for work, and in addition to sending out the usual circular, commenced a systematic canvass of the whole subject. The information gathered was duly tabulated and arranged for a final meeting of the committee to determine upon the report to be presented. In this connection the valuable work of the International Association for Testing Materials, in formulating Standard Specifications for Axles and Steel Forgings, was brought to the attention of the committee, and it was thought that the proposed specifications, as drawn up by the American section of the International Association, were, in the main, so comprehensive and satisfactory that, with slight modifications, they would be acceptable to the association.

On this account it was decided to report progress, and to ask the association to authorize the committee, and invest them with the necessary power to co-operate with the International Bureau of Tests, with a view of having such changes incorporated in the proposed specifications as would make them acceptable to the association, and to report to the next regular meeting of the association.

A TYPICAL SHOP TO SERVE A ROAD OR DIVISION EQUIPPED WITH 300 LOCOMOTIVES.

A Paper by L. R. Pomeroy, General Electric Co.

The items of expense entering into the cost of operation, for which the motive power department is more or less responsible, represent about 30 to 35 per cent. of the total operating expenses, of which labor comprises 12½ per cent., fuel and lubrication 12.7 per cent., and repairs 8.8 per cent. These items show the very narrow field or range in economies in which the motive power officer must confine his efforts in seeking to effect economies in his department. As the question of repairs represents nearly one-third of the items for which he is more or less accountable, the shop problem becomes quite important and worthy of careful attention.

Division of labor is to-day recognized as an essential characteristic of manufacturing. It has been found that in no other way can production be made so rapid and so economical in material and labor. To produce a manufactured article, a number of processes are required, each different from the other, in appliances used and in the character of skill required of its working force, but all co-operating to the same end—the production of a single, complete, marketable article. In designing a manufacturing plant, it follows that this differentiation of appliances and manual skill must be recognized if the best use is to be made of the appliances and of the men. The railway shop plant is a kind of manufacturing plant, and the same principles which apply to the successful operation of other manufacturing plants apply to its operation.

How to best subserve his own particular conditions is then the thing which the motive power officer has to consider. The factors which enter into this problem are many, but we think they may be gathered under the following heads:

1. Convenience of location in respect to the accommodation of the system as a whole:

2. Convenience of location with respect to centers of supply of material and labor, and

3. Advantages of location in respect to cost of land, buildings, taxes, etc.

Defects in shop design, causing inconvenient handling of material or movement of workmen, are permanent and cannot be removed. From the time the raw material is taken in hand until it is erected in the finished locomotive, its movement should be directed to the end. Shops, therefore, should be so laid out that the proper sequence of operations can be followed so as to minimize labor and lessen cost of operation.

Some general considerations governing the erection and design of new shops, as laid down by a Western manufacturer, are pertinent in this connection, and are as follows:

First. The most suitable manufacturing building is a ground-floor surface, protected from the weather and direct rays of the sun, without interfering with the light.

Second. A plant started on a scale however small should be capable of indefinite extension without expense in altering or in any way interfering with previous construction.

Third. Land enough should be secured in the first instance to avoid the future necessity of removal and abandonment of a plant at a loss, owing to lack of room.

Fourth. With land at $2,000 per acre, or less than 5 cents per square foot, it is cheaper to use land for one-story buildings than to save land by building more than one story.

Fifth. It is cheapest to support machinery directly on the ground. There is no vibration, no danger of heavily loaded floors falling when buildings are old, nor of upper floor loads falling upon the lower in case of fire.

Perhaps it is not too much to claim that all are quite agreed that the arrangement of erecting shops with longitudinal tracks, when provided with conveniently appointed cranes, is superior to the old form of transverse track arrangement with the accompanying transfer table and the numerous doors opening thereon, even if a traveling crane is provided.

Recently, however, several shops have been designed on the transverse or across-track plan, dispensing with the transfer table and attendant side doors for each pit. (Sketch plans, made from published cuts, illustrating this latter form, were shown, including a plan and section of the erecting, machine and boiler shops of the L. S. & M. S. Railway, at Collingwood, Ohio, a section through the erecting and machine shops of the P. & L. E. Railway, at McKee's Rocks, Pa., and a plan and section of the erecting and machine shops of the P. & R. Railway, at Reading, Pa. Also two designs on this order were shown, one by Mr. M. N. Forney, and the other by the late Howard Frye for the West Shore Road.

The design shown in the accompanying drawing is presented to show the author's idea of the typical shop designed to comply with the conditions indicated at the head of the paper. The erecting, machine and boiler shops are practically under one roof, compact, and arranged to facilitate the handling of material, reducing to a minimum the distance to be traversed by both men and material.

The longitudinal tracks in the erecting shop side are arranged to provide 25 ft. between centers, enabling, when necessary and desirable, the placing of engines between the tracks, thereby adding to the normal capacity of the shop; the capacity rating of the erecting shop, however, is based on the track capacity only.

As noted on plan, the erecting shop is nominally 400 ft. long, with a track capacity of 24 locomotives, allowing ample space at either end of shop and for a definite passageway between the head and rear ends of all engines standing on the tracks.

The cranes in erecting shop are in two units of 60 tons each, the combined capacity, when working in unison, enabling the handling of the heaviest type of locomotive in use at the present time.

As the cranes will not be utilized for lifting engines more than 10 to 15 per cent. of the time, two cranes are available for general use, when not employed in lifting and traversing engines, and both cranes are provided with rapid auxiliary hoists.

The boiler shop being a continuation or extension of the erecting and machine shops, one of the erecting shop cranes is available for use in the boiler department, when desired, while the other can be usefully employed in facilitating the erecting of engines, and yet both can be brought directly into service in either place, as the dictates of necessity or utility require.

The engines enter from the right, preferably by means of the center track, are lifted off their wheels and carried to any convenient or desired location. The wheels are then taken to the storage tracks provided, adjacent to the wheel and axle department, and receive attention in due course.

The machine shop side is divided into two bays; the one on the outside for the lighter tools served by light traveling air hoists locally arranged, as the tools and departments naturally determine; while in the other, nearest the erecting tracks, are grouped the heavy tools. This latter bay is provided with two cranes of 10 and 5 tons capacity, respectively. These cranes are provided with rapid hoists and serve all the tools in this bay, traversing the full length of the building and also available in the boiler end, serving the tools of this department and running clear into the riveting tower.

The question of tracks, both standard and industrial, should be considered and provided when necessary.

Steam and water pipes should also be provided, running the entire length of the shop; also electric cables with numerous taps for portable lamps.

While no arrangement for lighting is shown on plans, yet the scheme comprehends an adequate electric lighting system, with the necessary generator for same.

Compressed air mains to run lengthwise of the shop, and branch pipes attached to each post to run down to a point near the floor are shown. Numerous storage tanks located at convenient points should be provided to insure a steady and uniform pressure.

Tools.

The electric motor has taken its place as one of the everyday, hard-working, steady-going, reliable pieces of apparatus that is to be counted on and used with the same freedom that a pulley or a block and tackle would be applied in its appropriate place in the construction of a modern industrial plant.

Electric transmission places no restriction on the location of the machines, and each shop may be planned with a view of handling its product with least waste of labor and with greater convenience of access to the tools.

In order to insure the greatest amount of service from shop tools, a careful calibration and a predetermined rating of each is a *sine qua non*.

When the tools are carefully rated, and the best commercial speeds, as to feeds and cuts, covering the range of the tools, with reference to the material and product desired, definitely determined, a more uniform output from similar machines and the maximum output from all the tools is assured.

A plate giving this information attached to each tool places this information before the operator, so that no uncertainty as to which speed or cut to use to perform a given operation is possible.

The question of the limitations of life of a given tool is a subject often discussed, and the following extracts from the technical press are directly to the point:

Tools are not up to date when there is something else on the market which will do more work or do it at less cost for labor.

They need not necessarily be worn out to be wasteful by comparison.

In England the decision was to keep the old machinery turning over as long as it could be made to do its work. With us the decision was to make scrap of it as soon as a newer machine could be found which would produce sufficient increase of product to pay the required interest on the investment. And be it observed, the fundamental conditions were more favorable to frequent renewals in England than here, for until recently rates of interest have been uniformly lower there than here, while the cost of machinery there has called for a smaller outlay for a given equipment. In our rolling mills and steel works it is, we believe, a conclusion at which engineers have arrived that provision must be made for renewing them *in toto* every 10 years, and, in point of fact, we not long ago saw a rolling mill (by which term we now mean a set of rolls with its attached engine and appurtenances) which was in process of demolition and on its way to the cupola. That mill, we were told, had been built but five years before, to be, as it then was, a strictly modern and up-to-date mill, but the progress of improvement had made its demolition a necessary measure of economy.

This incident illustrates the American view of such matters. Not all American works have been so managed, but those that have not have been crowded to the wall by those that have. And it may be predicted with entire confidence that the process that has been at work between individual establishments will also operate between nations. It is a matter of easy proof—in fact, it is almost self-evident—that the American practice leads to the best use of capital, as well as labor, and that it must survive.

The English idea seems to be to regard a machine, once bought, as a permanent investment, or at any rate as one which is to be extinguished only by the operation of a suitable depreciation charge applied year by year.

Electrical Equipment.

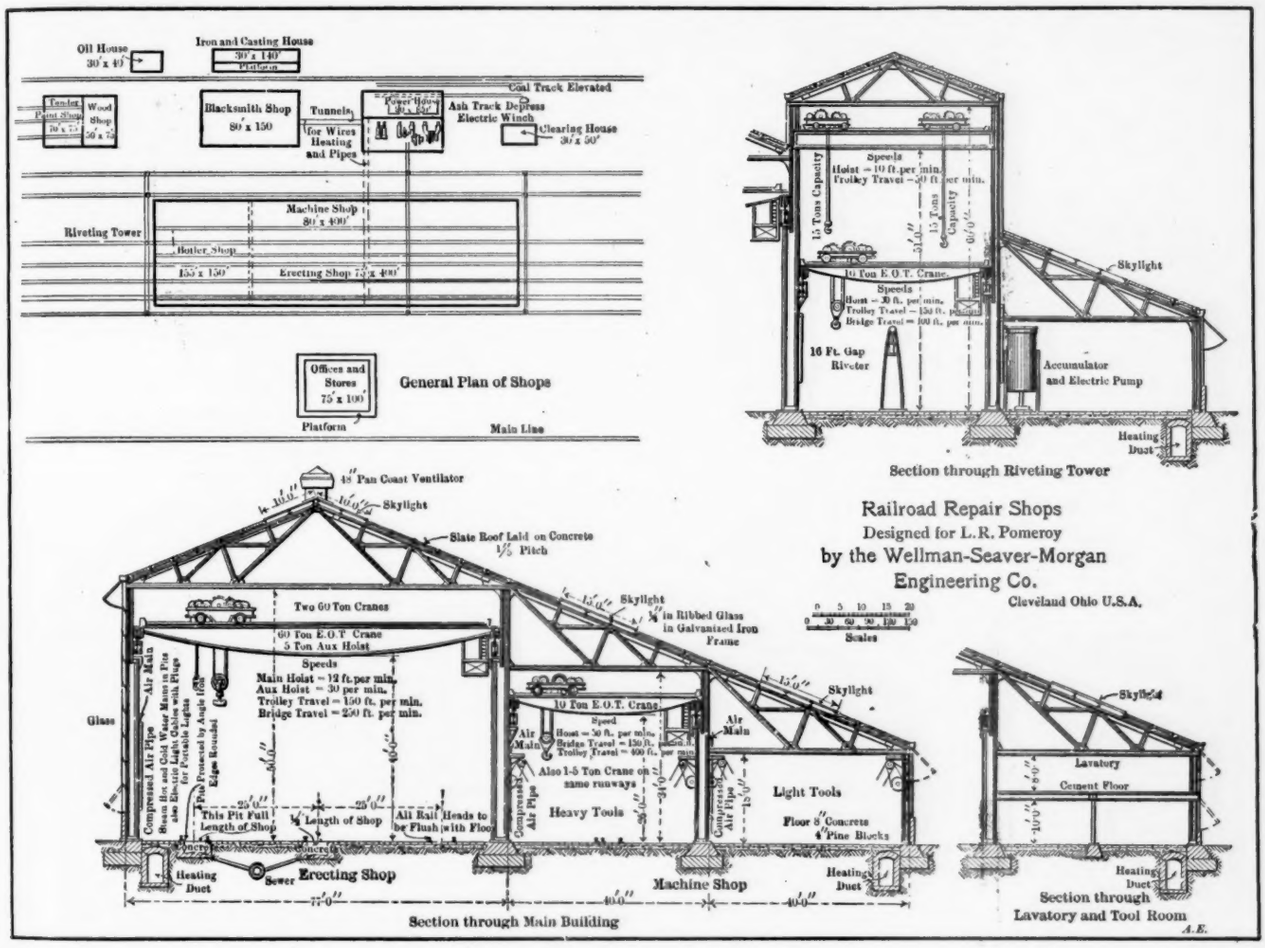
While the question of the individual location and arrangement of the tools has received careful attention, and we had at first contemplated showing this on an enlarged ground plan, we finally concluded to omit it, as such an arrangement is more or less determined by local conditions and circumstances.

At the present state of the art, keeping in mind rational and economical conditions, also being governed by conservative, rather than radical considerations, we would advise a judicious combination of the group and individual methods of driving.

Generally speaking, tools requiring more than five horse-power should be provided with individual motors, although there is no hard and fast rule for this, as the location of the tool with more or less reference to the work performed, the average running period, whether the work is constant or intermittent, and how much variable speed is a factor, are the governing features.

It is the writer's practice to make a careful study of each individual case, determine the space and distance to be covered, and arrange what seems best under the circumstances.

In numerous cases the work through the shop has been studied by means of templates of the governing sizes and pieces, drawn to scale, and these, worked over the plans, keeping in mind various combinations, exceptions and alternatives, have been of great assistance in determining the best location and groupings of the tools. Such groupings and arrangement has been the basis upon which the motor selection, type of drive or the method of applying same, has been determined.



Plan and Elevation of Typical Shop.

Power House.

The equipment of the power house to completely cover the scope of the foregoing plans, necessary power for tools, steam for smith shop and heating, etc., is as follows:

Two 400-H. P. and one 200 H. P. boilers, making a total of 1,000 H. P. Ordinarily, the two 400 H. P. units will drive the shop and the third unit can be used as a square; the light or summer load can be handled by one of the 400 H. P. units.

An air compressor capable of compressing 1,000 cu. ft. of free air per minute.

One 200 k. w. generator coupled directly to a 300 H. P. cross-compound engine.

One 150 k. w. generator coupled directly to a 225 H. P. tandem compound engine.

One 75 k. w. generator coupled directly to a 125 H. P. tandem compound engine.

This latter unit, besides taking care of the lighting, will handle sufficient power load to carry such departments as require to work overtime when the balance of the shop is shut down.

In summation:

2 400-H.-P. Boiler units	800-H.-P.
1 200-H.-P. Boiler unit	200-H.-P.
Total	1,000-H.-P.

1 200 K.-W. or 300-H.-P. engine
1 150 K.-W. or 225-H.-P. engine
1 75 K.-W. or 125-H.-P. engine

Total.....650-H.-P.

Suitable switchboard should be provided. Ample capacity of boiler feed and fire pumps should be provided, as also feed-water heaters and economizers.

Power tunnels are shown leading from power house to the machine and smith shops to carry all steam, water and air pipes, and provision is made for all electric cables and feed wires.

The absolute command of draft for the generation of the required quantity of steam, utilization of heat from flue gases made by improved forms of economizers, the ease of making ample provisions for large future capacity, and the low first cost of installation, as compared with the chimney, will commend the mechanical induced draft system in the construction of the modern power plant. With mechanical draft the labor of the fireman is much reduced, a cooler fire-room possible, with steadier steam and less labor in handling fires.

The heating of the machine and erecting shop, store house and office building should be by means of exhaust steam to stacks or coils, and the heated air circulated by means of fan blowers.

The various fan loads would be as follows:

Machine shop, 4-25-H.-P. motors	100-H.-V.
Wood shop	10-H.-P.
Storehouse and office 2-10-H.-P.	20-H.-P.
Total for heating	130-H.-P.
Blowers for smith shop	25-H.-P.
Exhaust fan for smith shop	25-H.-P.
Exhaust fan for wood shop	10-H.-P.
	60-H.-P. 60-H.-P.
Total fan load	190-H.-P.

Costs.

One of the most valuable fields of investigation for a shop foreman is that of cost of doing work on or by means of different machine tools, which are used in doing the work which he is required to supervise. One may say "that goes without saying," but in my experience, when you pin a foreman down as to the cost of different things you get very different replies. Some men, when you ask the cost of doing a certain piece of work—manufacturing, for instance, certain details of a locomotive—would give you the cost of the man's wages who runs the machine that manufactures this, taking the number of hours that he has to have the piece in the machine; another man will add to that the cost of the material that goes to make up the piece, but this is by no means the total cost of the manufactured part; in fact, it in general is rather a small percentage of the total cost. I recently had some investigations of this sort made in one of our shops, and I was rather surprised to find how much of the actual cost of manufacturing a certain article or doing a certain job of repair work was in the cost of moving the materials and appliances which are used to enable the man to do the job, and putting them away, in the grinding of tools, and of the incidental time that is taken up in manufacture. I had and am having this looked up in different shops, and as an example of what is being done in this direction, I will cite a case of boring cylinders, which is familiar to all railroad men. I have in my hand the statement of cost of boring cylinders of certain engines. I will simply read the data of the cost of this, with a view of showing the method which should be employed in arriving at the cost of doing this kind of work and of analyzing it, so that the different items of expense which enter into the total cost may be known and intelligent action taken upon them:

Boring Cylinders, Engine 298.

Right cylinder, before boring 16⅛ ins.; after boring, 16¼ ins.
Left cylinder, before boring, 16⅛ ins.; after boring, 16 9-32 ins.

	Hrs.	Mins.	Rate.	Amt.
Getting in boring bar	0	30	$1.90	$0.095
Putting bar in cylinder	0	45	1.90	.15
Putting up flex. shaft	1	0	1.90	.19
Rope broke and repaired	0	30	1.90	.095
Roughing in cut	0	35	1.90	.11
Finishing cut	0	30	1.90	.095
Counterboring back end	0	30	1.90	.095
Counterboring front end	0	15	1.90	.05
Repairing and grinding tools	0	30	1.90	.095
Changing bar	1	15	1.90	.24
Roughing cut	0	35	1.90	.11
Finishing cut	0	30	1.90	.095
Counterboring back	0	35	1.90	0.11
Counterboring front	0	15	1.90	.06
Taking down bar	0	20	1.90	.67
Helper on job	3	35	1.90	.67
	12	10		$2.31

In order that ways and means for the reduction in cost of work may be intelligently effected, we must first determine what the work is actually costing under existing conditions; by being armed with this information we may argue from facts, and the force of our statements will be much greater.

The storehouse, besides serving the useful function involved in its name, can be made still more valuable as the basis of an adequate and comprehensive cost-keeping plan, by using it as the "clearing-house" of the system.

The following in regard to the railway master mechanic was quoted:

"A successful master mechanic must be two-sided. He must not only keep the machinery under his charge in proper order, but he must discipline, direct and control the animated human machine that operates the inanimate tools or engines. He should, therefore, be a good mechanic as well as a good leader of men. He should be familiar with tools, and should understand theoretically and practically the locomotive and other steam engines, as well as the laws of combustion. He cannot ignore gas and petroleum motors. He should cultivate the habit of critically analyzing operating results shown in statements issued from his own and the accounting office. He should be a student of current technical literature. He should attend the meetings of technical societies, and under no circumstances should he fail to study their proceedings. He should cultivate a spirit of relentless self-criticism; should never be quite satisfied with what he has accomplished, and should determine to excel all others engaged in his particular line of work. To be a good leader of men, he should cultivate perfect patience, forbearance and self-control, remembering that no man ever controlled others who did not start by controlling himself. He should be even-tempered, or, if not born so, should not let any one discover it. He should be strictly just, granting cheerfully everything due his employees, while jealously guarding his employer's interests, curbing his generosity in spending funds intrusted to him. A man so qualified should make a successful master mechanic, but would not long remain one in the present day of keen competition in all branches of railroad service."—*J. Kruttschnitt, Pacific Coast Railway Club.*

SUBJECTS FOR 1903.

Committee—A. E. Manchester, Howard Stillman, Alfred Lovell.

1. A committee to be appointed and continued until after the 1904 meeting of the International Railway Congress, said committee to work in conjunction with the American Society of Mechanical Engineers, the American Institute of Mining Engineers and the International Association for Testing Material, in preparing standard specifications for locomotive forgings, and to report progress and results of their investigations to this association in 1903, and each successive year until their work is completed and the committee discharged.

2. What is the most satisfactory practice for setting flues in the firebox end of a locomotive boiler, and what is the best style and form of tool for setting and repairing same?

3. What is the best arrangement of drawbar and buffer attachment for use between engine and tender; what should be the form and relative strength of drawbar to the tractive power of an engine, and what offset in the bar is permissible?

4. What is the best kind of light in the locomotive headlight for economy per unit of light, and what standard constitutes sufficient light for the purpose?

5. Strength versus Size of Locomotive Boilers.—What will produce the greatest economy for a given weight of boiler—high pressure and boiler built strong enough to sustain same, or lower pressure with increased heating surface?

6. If the committee that now has question No. 4 for this year does not cover this point, I would suggest that the committee be continued, or a new one appointed, to determine what shall be the relative grate and heating surface for different kinds of fuel as applied to compound two or four-cylinder locomotives.

7. What is the best practice for painting locomotives and tenders, cost, durability and appearance all being considered, especially bringing out any economical appliances which have been utilized to assist in this work.

TON-MILE STATISTICS.

Committee—H. J. Small, C. H. Quereau, G. R. Henderson, G. L. Fowler.

When this committee was first appointed, to report to the convention of 1899, the title of its subject was: "Advantages of the Ton-Mile Basis for Motive Power Statistics." By some method of evolution the subject title has been changed to "Ton-Mile Statistics," and perhaps properly so, for the reason that the convention of 1899 accepted the ton-mile basis by passing the following resolution:

"*Resolved*, That it is the sense of this association that the ton-mile basis for motive power statistics is the most practical and encourages economical methods of operating, and that it is desirable that the heads of motive power departments urge its adoption on their managements."

This, so far as the association is concerned, practically disposed of the question as to the *advantage* of the ton-mile basis, and the adoption of the ton-mile basis in some form within the past few years by several large railway systems has proven the wisdom of the action taken by this association, and we think there are few, if any, members of this association who will now oppose the ton-mile basis as being the best basis for motive power statistics.

Further investigation of this matter by your committee, under the subject title of "Ton-Mile Statistics," develops complex questions and conflicting opinions as to what the statistics should include.

It has been thought wise to confine the present report to discussion of the general principles involved, in the belief that with these settled, the details can be worked out to better advantage afterward, and numerous chances of confusion and an unnecessarily prolonged discussion be avoided.

It may seem out of place that an association of motive power officers should venture and discuss opinions concerning operating department statistics, but in view of the fact that this association was among the first to discuss the question of statistics on the ton-mile basis, and has constantly urged their use, that this basis is

not as generally used for operating as for motive power statistics, that we are convinced that its general use for the operating department would result as beneficially as experience has shown it has for the motive power department, and that the use of the same basis for both departments will further result in economies in the statistical department we venture our opinions and suggestions.

In considering this subject, we should view it in the light of what the statistics should include to best promote and suggest motive power economies; should statistics include all classes of service, as passenger, freight, switching and work train? In computing ton-mileage should weight of locomotive, tender and caboose be included? Should statistics be segregated to show main line and branches separately? Should passenger and freight business be divided into fast and local?

While your committee is not in harmony on all these points it is deemed advisable to present an argument covering all the questions and request action thereon by the association.

[Editor's Note.—This argument is exhaustive. The conclusions, as summed up in resolutions offered, are given as follows:]

Acting under authority given it at the convention of 1901, your committee corresponded with the American Railway Association and the American Railway Accounting Officers, and learns that, while both of these associations have committees on mileage statistics at work, nothing definite has been decided upon as regards ton-mile statistics, and it is the belief of your committee that any action taken by this association at this time would receive the careful consideration of the above associations. The statistician of the Interstate Commerce Commission also expressed interest and promise of co-operation.

The following resolutions embody the general principles on which your committee requests the action of the association, with a view to presenting the results of such action to the American Railway Association for its approval:

"*Resolved*, That it is the sense of this association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

To make the record complete, we include the following, passed unanimously in June, 1901:

"*Resolved*, That it is the sense of this association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes."

We would amend this by inserting the words "and caboose" after the word "locomotive."

"*Resolved*, That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved*, That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved*, That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service should be each further grouped under 'Through' and 'Local.'

"*Resolved*, That the statistics of branch lines and main lines should be kept separately.

"*Resolved*, That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved*, That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved*, That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

MASTER CAR BUILDERS' ASSOCIATION REPORTS.

(Concluded from July.)

SPLICING PASSENGER CAR SILLS.

Committee—J. S. Lentz, Mord Roberts, T. W. Adams.

Your committee having received drawings of various forms of splices, and considering the subject of sufficient interest and value, determined to make a test of the various types most generally used and that could be tested with the facilities at hand. All tests were made in wheel presses. The first series were made at Sayre, Pa., under the direction of Mr. J. Hawthorne, master mechanic, and the second set at Norwood Central, Mass., by Mr. T. W. Adams. The result of the two series of tests show that the lock splice, as commonly used, is not as strong under compression and it would appear not as strong under transverse loading as the step splice, and very little stronger than some of the other forms of splices. It would seem to the committee that if the splice is properly located over a needle bearing, so as to eliminate vertical strains, the step splice is much superior. It is also apparent that this form, besides being stronger than the lock splice, can be applied at less cost, especially in the repairing of cars. Two forms of splices are shown, Figs. 1 and 2, known as the Pullman standard, a practice most generally followed for splicing intermediate and side sills, and Fig. 3, the step splice, which stood the most satisfactory tests, and which is recommended for all sills. Your committee is of the opinion that under these existing conditions both of these forms should be submitted to letter ballot, as recommended practice, and in the event of neither receiving the required two-thirds vote on the first ballot, the one receiving the largest number of votes be again submitted to ballot.

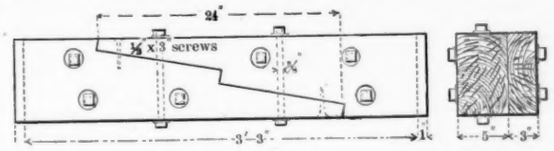


FIG. 1

Sayre Test
Compression
Maximum Load Before Breaking 80000 lbs.
Decrease in Length 3/16"
Breaking Load 82000 lbs.

Norwood Test
Compression
Maximum Load 80000 lbs.
Decrease in Length 3/16"
Transverse
Maximum Load 26000 lbs.
Splice Opened ¼" at one end

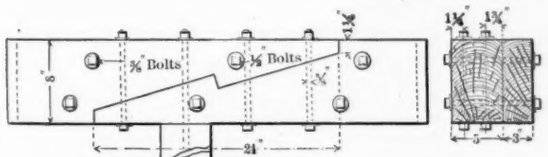


FIG. 2

Sayre Test
Compression
Maximum Load Before Breaking 110000 lbs.
Decrease in Length ⅛"
Breaking Load 120000 lbs.

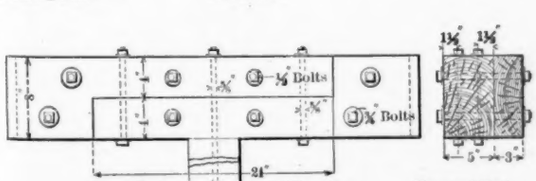


FIG. 3 & 9

Sayre Test
Compression
Maximum Load Before Breaking 190000 lbs.
Decrease in Length ¼"
Breaking Load 200000 lbs.
Transverse
Maximum Load 42000 lbs.
Deflection Before Breaking 1¼"

Norwood Test
Compression
Maximum Load 185000 lbs.
Transverse
Breaking Load 19500 lbs.

A.E

Tests of Passenger Car Sill Splices.

TESTS OF M. C. B. COUPLERS.

Committee—R. N. Durborow, W. P. Appleyard, Joseph Buker, W. S. Morris, F. H. Stark.

Editor's Note.—This standing committee had not been able to make tests because the committee on draft gear required the use of the Altoona testing machine. This led to a recommendation that the association should build a new machine at Purdue University. The committee also recommended improvements in the contour and worn coupler gauges. The suggestions with reference to strengthening couplers themselves are reproduced as follows:

Your committee is sure, and the opinion seems to be very general, that the abandonment of the link-pin holes and link slots would be the greatest improvement to the automatic coupler that could be made at the present time, but there still seems to be some objection to making this change until some supplementary device is found which will be entirely satisfactory and adequate for handling cars around short curves in mill yards and at warehouses, as well as on and off floats where the water level varies greatly. Your committee has experimented with several devices for handling cars around short curves, which are partially successful, but which cannot be said to meet all the requirements of the service, and on this account we feel compelled to give up recommending the change at this time. From an inspection of 400 knuckles of various different kinds, taken at random from a scrap pile, it was found that 37½ per cent. of the failures were due to the link-pin holes and 21 per cent. to the link slot, while 12 per cent. and 29½ per cent. of the failures were due to the tail and to the knuckle-pin hole, respectively, which plainly shows how great a saving would be effected by the use of the solid knuckle. It also shows that there is a great weakness at the knuckle-pin hole, where the trouble will be much harder to remedy. It seems unfortunate that a little extra inconvenience at these local points should outweigh in importance the very great advantage and saving to be gained all over the country.

Your committee has made some few tests of the head presented last year for experiment, which suggest first of all that it is impracticable to use a 1⅝-in. pin in a head 8 ins. between lugs. For

these tests a type of coupler was used in which the end of the tail of the knuckle, fitting squarely against the head, showed, after the specification test, that the pin had been relieved of considerable punishment. Even in this type of coupler the 1⅝-in. pins in the three tests made were bent ¼ in., ¼ in. and 3-16 in., while in two of them the knuckle wold not open after three blows at 5 ft. and two blows at 10 ft. This shows plainly that the longer pins will bend in the holes unless they have large enough section to give them the required stiffness. A striking test of a coupler of the same type and same distance between lugs, but with 3-in. lugs instead of 2½-in. and a 1¾-in. knuckle pin showed a perfectly straight pin after the test, and the knuckle and locking devices remained operative until the seventh extra blow at 10 ft., which broke the knuckle through the knuckle-pin hole, and the pin then only showed a scant 1-16-in. bend. From this it seems that a knuckle with an 8-in. hub can hardly be recommended with the present contour, from the fact that the 1⅝-in. pin bends too much, while the 1¾-in. pin increases the present weakness through the knuckle-pin hole and at the lugs of the bar. The 13-in. face for the knuckle, as suggested last year, does not seem advisable, since one 10 ins. deep proves to be stronger through this part than through the hub. In view of the fact that we hope very soon to be able to abandon the link-pin holes and link slots, which will make this the strongest part of the knuckle, and transfer almost the entire breakage to the knuckle-pin hole, it seems that this extra depth is not the direction toward which we should be working. We would rather look for some way to get a bar with stronger lugs as well as a knuckle much heavier and stronger through the knuckle-pin hole, where even now, with the 1⅝-in. pin, the percentage of breakage is very great. To do this would mean a change in contour, which might be done so gradually that little difficulty would be experienced. Your committee realizes that this is a serious proposition, which will have to be faced sooner or later, in order to get the additional strength in the lugs of the bar, and in the pin, as well as in the knuckle; at all of which places the failures are becoming very serious. Your committee thinks that increased strength of lugs will be better obtained by an increase in section rather than in depth, which may also be said of the knuckle at the pin hole. Another feature of the experimental head presented last year is the increase of 1 in. in the distance from back of horn to inside face of knuckle. Some types of couplers may need this for strength or for providing more room inside for knuckle and locking devices, while other types do not need it. As your committee does not know of any reason why this distance should be maintained exactly the same, knowing well that it cannot be less than it is now or much greater on account of the extra weight of metal unnecessarily involved, it is recommended that a little latitude be allowed to the discretion of the makers, and that this measurement be not specified.

To sum up, your committee believes that a head 11 ins. or 12 ins. deep, with a 9-in. or 10-in. face for a solid knuckle, the contour of which should be changed to admit the use of a 1¾-in. pin, would meet all the requirements of the heaviest service, but thinks that another year's experience with these heavier types is necessary before any definite recommendations can be given.

Five comparative pulling tests have been made with the increased butt riveted up in different combinations, as per drawing herewith (not reproduced—Editor), the approximate results of which are also shown. From these results it appears that the strength of the lips with two rivets is very much in excess of any direct drawbar pull ever found in service. Whether a third rivet is needed to give extra stiffness or to stand excessive shocks, only experiment can determine, which also will be necessary to prove the advantage of the short rivet method over the old one. From the pulling tests very little information on this subject could be gained, except that after test 2 the rivets were all much looser than after test 3, so your committee does not recommend a change until more information can be obtained from service conditions, which could be best had by using the two methods at the different ends of the same cars. A little more experience with these butts will also give more information concerning the comparative facility with which the work can be done. In the old method your committee suggests that the rivets be inserted from the opposite sides of the yoke, which results in having one hole well filled on each side. It is also suggested that the fillets at the lips of the yoke always be kept smaller than the radius of the corners of the butts.

SIDE BEARINGS AND CENTER PLATES.

Committee—B. Haskell, H. M. Pfleger, W. H. Marshall, J. W. Luttrell, T. W. Demarest.

Your committee on Side Bearings and Center Plates was continued from last year, with instructions to report on (1) a design of center plate, with a view to adopting dimensions for standards or recommended practice; (2) the location of side bearings; (3) uniform relation between center plate and side bearing; (4) the merits of anti-friction side bearings for relieving the center plate from part of the load; (5) will the use of anti-friction side bearings diminish the resistance between the wheels and rails.

Center Plates.

Your committee has endeavored to obtain data which would enable it to present for your consideration a form of center plate for adoption as standard. Under the direction of Mr. T. W. Demarest, Superintendent of Motive Power, P. C. C. & St. L. R'y, a series of tests has been conducted of different forms of center plates and side bearings, and the results, as far as they have been completed, are given herein.

The object of the test with center plates was twofold; first, to ascertain the best metal for center plates; second, to define, if possible, the best shape. In making the test, two male center plates were bolted on the opposite sides of one end of a lever, each male center plate in turn engaging in a female center plate; the entire construction being forced together by a hydraulic press, from which were obtained total pressures ranging from 15.3 tons to 40.8 tons. The end of the lever in turn was moved through an arc by means of an air cylinder; an indicator and reducing motion being attached, in order to ascertain the amount of work done in turning the male plates in the female plates under the different pressures obtained.

The result of these tests is shown in detail, both graphically and in statement form, on data sheets Nos. 1 to 8, inclusive, and statement sheet No. 9 attached; two sets of sample cards are also shown. The tests for side bearing friction were made in practically a similar manner, with the exception that the lever was pivoted at a point which would correspond to the average distance of side bearings from king bolt.

In order to ascertain, if possible, the best material for center plates, a number of plates were made as per plate "A," of three different materials: cast iron, malleable iron and cast steel. We were unable to obtain pressed steel plates of equivalent area or shape. The area, generally, of the plates was 100 square inches.

Test No. 1 of this series was made with the castings as they were received from the manufacturers, with no dressing or cleaning whatever. The cast steel, which gave the highest resistance, was extremely rough, had thick scale, fused patches on the surfaces, lumpy fillets, fins around the core holes, etc. The cast iron was not much better, and as a consequence the friction is close to the steel. The malleable plates were very smooth, clean castings, and gave a very much lower resistance. The results of this test show the difference in friction or resistance due to the varying smoothness of the surface.

Test No. 2 of this series was made by grinding the surfaces with an emery wheel, and chipping off fins and lumps in the fillets. This attention is assumed to be about as much dressing as it would be practicable to give the plates in actual practice. The scale was not removed, the casting simply being made smooth. In this test the resistance of the cast-iron and malleable-iron plates varies very little, if any, from the resistance obtained in the first test. The resistance of the cast-steel plates, however, has fallen most materially. The large drop in resistance of the steel plate was thought to be due to the crumbling of the thick, porous scale into a powder, which acted as a lubricant. This view was sustained by the fact that in the next test, with this same plate lubricated, there was but little further drop in the friction, the powdered scale in the latter instance preventing good lubrication.

In test No. 3 the same plates were taken as in previous tests and lubricated. The results of the lubrication are shown very conclusively in the very great drop in resistance.

In order to ascertain, if possible, if the low friction of the cast steel in test No. 2 was due to the powdering of the scale, the cast-steel plates were put in a lathe and the scale turned off and surfaces made smooth. They were again tested and the resistance was found to be lower than before the scale was removed from the surface. The effect of lubrication in test No. 2 practically eliminates the effect of the metal, as the plates of the different materials, when lubricated, have practically the same resistance.

The object of the second series of tests was to determine the effect of the shape of the contact surfaces. Having found the effect of rough castings in the first series of tests, all plates were smoothed and fitted. All plates were made of the same metal, cast iron, and all except that designed by Mr. Klohs, for the Master Car Builders' committee, had 100 square inches area of contact surfaces; the latter plate had 76 square inches. The results from test of flat plate in series No. 1 were taken for comparison with the curved and spherical plates in series No. 2, and it was expected that the flat plate would have the lowest friction on account of the tendency of the inclined surfaces of the other plates to wedge together. The results obtained from the tests do not at all confirm the theory. They do not show the superiority of the flat plate, and they do show an abnormally low friction for the plate designed by Mr. Klohs. The curves, as on general data sheets Nos. 4 and 5, show very plainly, as in the first series of tests, the good effect of lubrication, and indicate that when well lubricated the shape of the plate does not materially affect the resistance. The tests with the lubricant do show, however, that the resistance of the flat plate is lower than the spherical plate "X" and curved plate "B," and about the same as the Klohs plate. We can see nothing in the contour of the Klohs plate which would tend to produce lower resistance than we have obtained from the spherical plate "X." The unsuspected results are due, we believe, to the condition of the surfaces of the plates. The flat plate required but little grinding and fitting to give it a good bearing. The spherical and curved plates, however, fit badly in the rough, and required hard grinding, filings, etc., to bring them to a reasonable fit. The final condition of the surfaces was, therefore, very much better with the spherical and curved plates than with the flat plate.

Further tests in this series were made with special plates, namely, a small experimental plate "C" with flat surfaces, designed to be used without a center pin, and having a face only 4 ins. in diameter, with the idea that it might be possible to use such a plate in conjunction with a roller or other low friction side bearing to assist in maintaining the balance of the car. It was desired to have this plate chilled, as only a very hard surface could stand the heavy pressures. The plates were received soft from the foundry, however. The friction of this plate is very low, but cut badly both when dry and when lubricated, the cutting in both instances taking

place in the center of the plate. The second special plate tested in series 3, as shown on data sheet No. 6, was the ball-bearing center plate used by the P. & L. E. R. R. This plate gave the lowest resistance recorded under the conditions. The balls lie in pockets, which, in length, are about twice the diameter of the ball, and enough larger in width than the diameter to allow the ball to roll freely. The bottoms of these pockets curve upwards at the ends, so that the ball begins to roll up hill as soon as it leaves the central position, and as the slope of the pocket is curved, the resistance of the plate to revolution increases as the ball rolls up the slope. The cards taken in this test (samples of which are attached) show a gradually ascending line to a point where the ball seems to lock and stop rolling; the top plate then slides on the balls. The starting and final resistance is shown in tables and on curves for each pressure.

All tests, both of center plates and side bearings, show the desirability of thorough lubrication, the castings to be smooth, but scale allowed to remain on. A thick grease, furnished by the Galena Oil Company for the purpose, was used for lubrication. It is impossible to say how long the grease would last in service. The ball plates and roller side bearings gave very good results, although the ball center plate was badly cut in the upper groove by locking of balls in the pockets. Further, with the larger plates, that is, all plates with the exception of small flat plate "C," no cases of cutting, even under the pressures used, were experienced when there was a good bearing over the entire surface.

It will be noted in the statements that the resistance of the plate to turning is reduced to the wheel flange. We regret that our tests have not been comprehensive enough to permit us to make definite recommendations as to minimum contact area of plates under definite loads, the shape of the plate, or the material from which it should be made. The machine used was rather crude and it is being redesigned with the idea of carrying these tests to a conclusion.

Anti-Friction Side Bearings.

The fourth and fifth subjects assigned to your committee relate to anti-friction side bearings, and are as follows:

The merits of anti-friction side bearings for relieving the center plate from part of the load.

Will the use of anti-friction side bearings diminish the resistance between the wheels and rails?

For the committee to determine these qualifications it would be necessary to conduct a series of tests extending over a period of years. This was thought unnecessary at the present time. A circular was therefore addressed to each member asking his co-operation to the extent of furnishing to the committee the result of such tests as had been made, and which was available. Of the members replying those giving opinions or furnishing data control about one-fifth of the car equipment represented in the association.

The following results of tests of side bearings were submitted by members in answer to the circular of the committee, and are given below as bearing on the general subject: (The other replies are omitted.—Editor.)

Pittsburg & Lake Erie R. R. Co.

On June 1, 1897, one 60,000-pound capacity gondola car was equipped. The construction consisted of four steel balls 2¼ ins. in diameter, between two malleable-iron center plates, the lower plate having four grooves equally spaced, 4 ins. long, ¼ in. deep at the center, running out to nothing at the end. Lengthwise the grooves conformed to the radius of the bearing surface of the center plate. The upper plate had a groove ¼ in. deep, corresponding to the diameter of the balls and extending all the way around. The side bearings had each one steel ball of same diameter as those used in center plates; each bearing had a groove 15 ins. long, same diameter as the ball, straight on the bottom, but curved to proper radius. Balls were protected by deep flanges on each bearing, the top passing down over the outside of the lower. The ends of the flange on upper bearing were cut so as to permit of the greatest curvature of truck.

After the car had been in service three years, proving clearly that the device was entirely practicable, a careful test was made to establish its value in the way of reducing flange and rail wear on sharp curves. A turntable 7 ft. long was made so as to determine, by the use of a dynamometer, the actual power required to displace a truck 2 ins. at the end, or 4 ins. in its length, equaling a 154 degree curve. The appended report is the result of the trial:

First Test.

Flat center plate and side bearing, with ⅛ in. deflection of body bolster resting on side bearing:

	Resistance	
	Pounds.	Per Cent.
Required to start truck	800	100
Required to displace truck 2 ins.	1,100	100

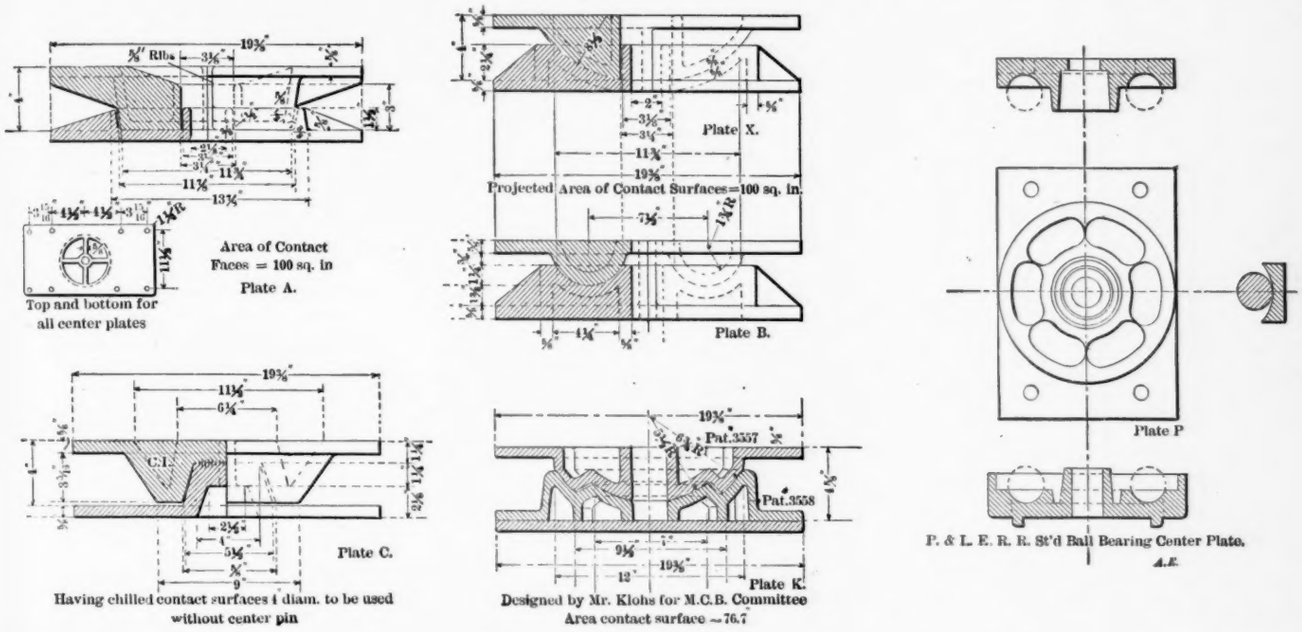


Plate A.
Area of Contact Faces = 100 sq. in
Top and bottom for all center plates
Plate X.
Projected Area of Contact Surfaces=100 sq. in.
Plate B.
Plate C.
Having chilled contact surfaces 4 diam. to be used without center pin
Pat.3557
Pat.3558
Plate K.
Designed by Mr. Klohs for M.C.B. Committee
Area contact surface = 76.7
Plate P
P. & L. E. R. R. St'd Ball Bearing Center Plate.

Side Bearings and Center Plates.

Second Test.

Flat center plate, without side bearing:

	Resistance	
	Pounds.	Per Cent.
Required to start truck	275	34
Required to displace truck 2 ins.	525	48

Third Test.

Hartman ball-bearing center plate and side bearing, with ⅛ in. deflection of body bolster resting on side bearing:

	Resistance	
	Pounds.	Per Cent.
Required to start truck	75	9
Required to displace truck 2 ins.	450	40

Fourth Test.

Hartman ball-bearing center plate, without side bearing:

	Resistance	
	Pounds.	Per Cent.
Required to start truck	75	9
Required to displace truck 2 ins.	325	29

This report, to our mind, clearly indicates two things, namely: We should have a frictionless side bearing to assist cars around curves with high outside elevation, but on straight and level track the load should be carried on the center plate, and by all means on a ball bearing. The most valuable feature in the center plate in question is the dish in the grooves in the bottom plate, which answers two purposes, one being to keep the balls properly spaced and the other the tendency to straighten the truck quickly after leaving a curve, this being explained by the fact that the sluing of the truck on a curve forces the balls up the inclined plane of the grooves, and as soon as straight track is reached they naturally gravitate back to their proper position.

For your information we append a report of the service of the car in question:

Car built	April, 1896
Equipped with Hartman appliance	June, 1897
Miles run from June, 1897, to date	11,323
Approximated loaded mileage	7,548
Capacity of car	60,000
Tons carried one mile	226,440

Wheels show no flange wear up to date.

The perfect condition of the wheel flanges demonstrates its value, not only as increasing the life of the wheel, but reducing train resistance.

Duluth & Iron Range R. R. Co.

Service of Automatic Frictionless Side Bearings. Effect Upon Flange Wear.

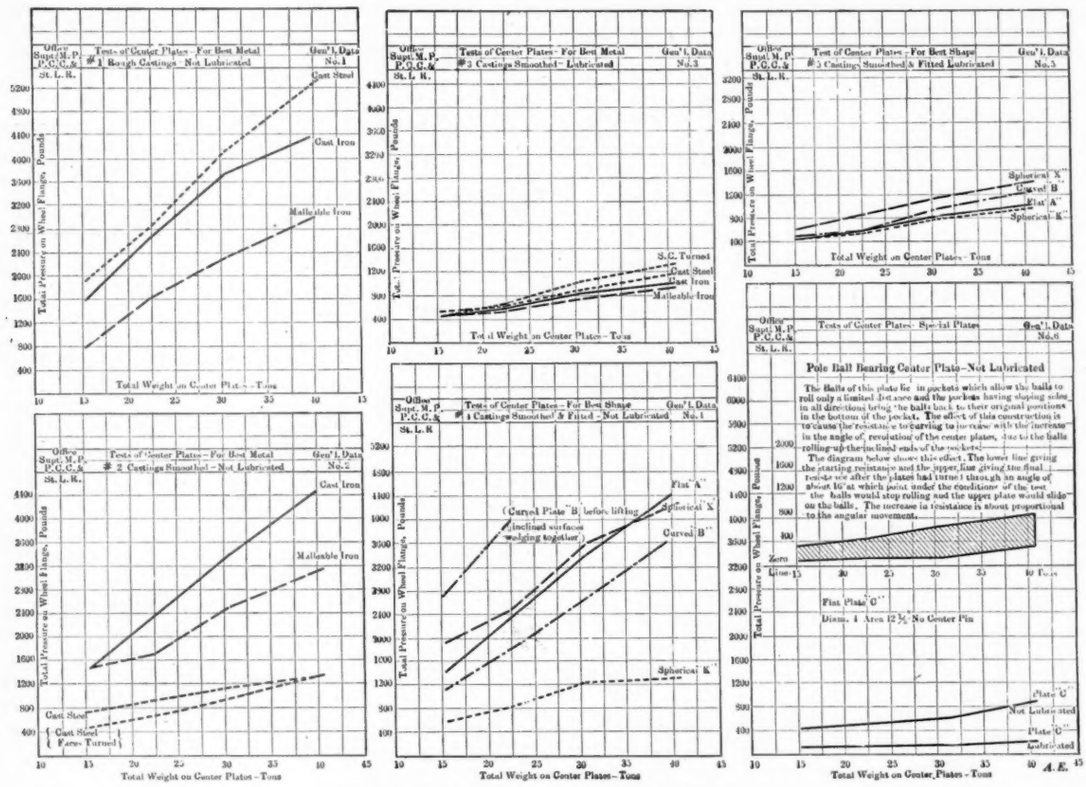
Year.	Wheels Removed. All Defects.		Removed for Sharp Flanges.	Per-centage.
1899	998		254	25.5
1900	2,248*		463‡	20.6
1901	1,815†		322	17.7
1902 (Jan. & Feb.)	372		24‡	
	6	Approximate for year	6	
	2,232		144 approximate.	06.0‡

bearings for having the flanges worn. By comparing 300 ore and flat cars with the automatic frictionless side bearings with 300 cars with plain bearings for 1901, it was found that while 101 wheels were removed for sharp flanges from the cars having plain side bearings, only 16 wheels were removed for having the flanges worn, from those cars equipped with the automatic frictionless side bearings.

The question of the effect of the automatic frictionless side bearings on flange wear alone is presented, because the wear of the wheel flanges can be easily and definitely ascertained, but while the other economies and advantages are equally apparent, they cannot be so accurately determined. It will be readily appreciated, however, that this reduction in flange wear shown means an equivalent reduction in rail wear, and a proportionate decrease in the draft of trains, and consequently a reduction in the cost of transportation. Again, the capacity and the life of the car bolsters are increased, and the cost of truck repairs considerably lessened.

Conclusions.

Taking up the divisions of this subject, as outlined at the beginning of this report, (1) a design of center plate, your committee presents the results of tests already made, which show the necessity for further tests in order to determine conclusively what should be the minimum area of contact of plates under definite loads, the shape of plate and kind of material. Owing to lack of time and the necessity for redesigning the machine, in order to complete the tests, your committee would ask to be continued another year, in order that it may complete its work.


Office Supt. M. P. P.C.C.&St. L. R.
Tests of Center Plates—For Best Metal
#1 Rough Castings Not Lubricated
Gen'l Data No. 1
Cast Steel
Cast Iron
Malleable Iron
Total Pressure on Wheel Flanges, Pounds
Total Weight on Center Plates—Tons
Tests of Center Plates—For Best Metal
#3 Castings Smoothed—Lubricated
Gen'l Data No. 3
S.C. Turned
Cast Steel
Cast Iron
Malleable Iron
Test of Center Plates—For Best Shape
#3 Castings Smoothed & Fitted Lubricated
Gen'l Data No. 5
Spherical "K"
Flat "A"
Curved "B"
Spherical "K"
Tests of Center Plates—For Best Metal
#2 Castings Smoothed—Not Lubricated
Gen'l Data No. 2
Cast Iron
Malleable Iron
Cast Steel
Cast Steel (Face Turned)
Tests of Center Plates—For Best Shape
#4 Castings Smoothed & Fitted—Not Lubricated
Gen'l Data No. 4
(Curved Plate "B" before lifting inclined surfaces wedging together)
Flat "A"
Spherical "K"
Curved "B"
Tests of Center Plates—Special Plates
Gen'l Data No. 6
Pole Ball Bearing Center Plate—Not Lubricated
The Balls of this plate lie in pockets which allow the balls to roll only a limited distance and the pockets having sloping sides in all directions bring the balls back to their original positions in the bottom of the pocket. The effect of this construction is to cause the resistance to curving to increase with the increase in the angle of revolution of the center plates, due to the balls rolling up the inclined ends of the pockets.
The diagram below shows this effect. The lower line giving the starting resistance and the upper line giving the final resistance after the plates had turned through an angle of about 16° at which point under the conditions of the test the balls would stop rolling and the upper plate would slide on the balls. The increase in resistance is about proportional to the angular movement.
Zero Line
Flat Plate "C"
Diam. 4 Area 12½" No Center Pin
Plate "C" Not Lubricated
Plate "C" Lubricated
A.E.

Tests.—Side Bearings and Centre Plates.

*An unusual condition affected this year's record. Over 60 per cent. of the removals, after deducting the wheels taken out for sharp flanges, were removed for flattened wheels in service.

†The automatic frictionless side bearings were in service all this year and affecting flange wear.

‡No removals for sharp flanges on cars with roller bearings.

Not considering the 200 cars built by the Illinois Car and Equipment Company, in 1899, there were 512 ore, flat, box and logging cars equipped with automatic frictionless side bearings in 1899 and 1900. Exact dates of applications of the side bearings to 278 ore cars, 38 box cars and 70 flat cars (386 cars in all) in 1899 and 1900 are known, and also the dates of six applications to ore cars in 1901.

The wheel records show that for the year of 1900, after the automatic frictionless side bearings had been just applied, but had not been in service long enough to have appreciable effect upon the wheel flange wear, 463 wheels were removed from box, ore, flat and logging cars for sharp flanges. During 1901, when the bearings were in service on 512 old cars of these classes, and materially affecting the flange wear, only 322 wheels were removed for worn flanges; a reduction of 30 per cent., notwithstanding that the wheels were an average of four years old when bearings were applied, that the car mileage had been increased, that train hauls had become greater, and that the equipment was one year older.

The indications are that the flange wear of 1902 will be decreased in even greater proportion, as the effect of the side bearings on the service in general approaches its limit.

The service of 52 ore cars equipped with the roller bearings was compared to that of 52 cars with plain side bearings (the car numbers selected at random) for 1900.

While no wheels whatever were removed from the 52 cars with the roller bearings, 17 wheels were taken from the cars with plain

Attention is called to the reduction in flange resistance by lubrication, the lubricant being a thick grease.

As already stated, the second and third divisions of this subject, namely (2) location of side bearings and (3) the relation between side bearings and center plates, are so closely allied to the first, that your committee has nothing definite to recommend in this connection at the present time. The replies received to the circular of inquiry from eighteen members show a variation in distance, center to center, of side bearings and center plates, from 24 ins. to 32½ ins.

The height of center plates varies from 2½ ins. to 7 ins.

As to the (4) merits of anti-friction side bearings for relieving the center plate from part of the load, from the replies received from the members it would seem that opinion is about equally divided. Your committee is of the opinion, however, that with a center plate of proper design and material, and a truck and body bolster of sufficient strength, the load can and should be carried on but one bearing point, namely, the center plate.

As for the fifth subject, resistance between wheels and rails, it is the opinion of your committee, and this opinion is substantiated almost unanimously by the replies received from the members, that the use of anti-friction side bearings will diminish this resistance.

Attention is further called to the fact that when side bearings are in contact the pressure against wheel flanges is greater than with center plates alone in contact.